Cardiovascular Psychophysiology

Returning to last time

The Polygraph

- Does not assess lying
- Assesses emotion/arousal
- Has an unacceptable high false positive rate
- Especially problematic for low base-rates of deception (e.g. screening)
- Appears to remain in use because it is useful for eliciting confessions
- See the 60-minutes segment: http://www.polygraph.com/media

NRC (2003) Key Conclusions

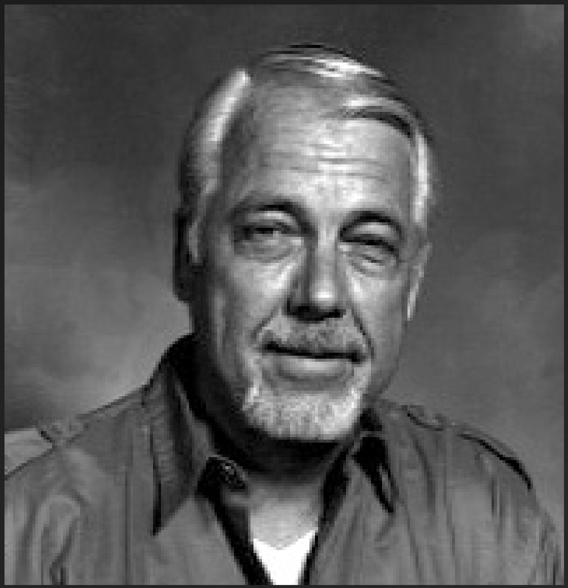
- “What is remarkable, given the large body of relevant research, is that claims about the accuracy of the polygraph made today parallel those made throughout the history of the polygraph: practitioners have always claimed extremely high levels of accuracy, and these claims have rarely been reflected in empirical research.”

- “Almost a century of research in scientific psychology and physiology provides little basis for the expectation that a polygraph test could have extremely high accuracy.”

Roadmap

- Abbreviated History and Overview of the Conventional Polygraph
- Limitations to Conventional Polygraphy
- Overview of alternatives: Assessing recognition

The GKT as an alternative to Traditional Polygraph Procedures



- **Guilty Knowledge Test (GKT)**
  - **Devised by Lykken(1959)**
  - **Can utilize Skin Conductance or other measures (e.g. Event-Related Brain Potentials)**
- **Sometimes termed "Concealed Information Test" (CIT)**

Guilty Knowledge Test (GKT)

- The GKT does not assess lying as indexed by fear of being detected, but probes for guilt as indexed by recognition
- A series of questions is devised, each having several alternatives, only one of which is true about the crime in question
- Chances of an innocent person looking guilty on a 10-item GKT are $1/5^{10}$.

Assessing Recognition: For Specific Incidents Investigations

- Used when information about a crime or event is available that only a real culprit would know
- Series of questions constructed, only one of which has correct critical detail

Regarding the abduction location, do you know for sure it was…

1. … at a Toy Store?
2. … at a Shopping Mall?
3. … at a City Park?
4. … at a Friend's House?
5. … at School?
6. … at a Restaurant?

Other questions about
- Time abductee taken
- Clothing worn
- etc. for 6-10 questions

- Subject instructed to answer "no" to each item, so that if guilty, subject would be lying to the critical item.
- Critical item never positioned at beginning.
- A consistent peak of physiological response on one critical alternative suggests guilt.

GKT Accuracy: Lab Studies

Study (1st Author, Yr)	N	Percent Correct Guilty	Innocent
Lykken '59	98	88	100
Davidson '68	48	92	100
Podlesney '78	18	90	100
Balloun '79	34	61	88
Giesen '80	40	92	100
Bradley '81	192	59	89
Bradley '84	16	100	100
Iacono '84	55	91	100
Steller '87	87	85	100
Iacono '92	71	87	71
O'Toole '94	45	77	94
Study Median	**48**	**88**	**100**

GKT – Box Score, and Concerns

- Superior to CQT, especially in protecting the innocent
- Resistance to use among those in the polygraph community
  - Concern about applicability, especially in high profile cases
  - The GKT for OJ
- Despite limitations of CQT, may have utility for eliciting confessions
- Over 5,000 GKT tests given in Japan each year, for example

frontiers in
PSYCHOLOGY

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The current and future status of the concealed information test for field use

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The Concealed Information Test (CIT) is a psychophysiological technique for examining whether a person has knowledge of crime-relevant information. Many laboratory studies have shown that the CIT has good scientific validity. However, the CIT has seldom been used for actual criminal investigations. One successful exception is its use by the Japanese police. In Japan, the CIT has been widely used for criminal investigations, although its probative force in court is not strong. In this paper, we first review the current use of the field CIT in Japan. Then, we discuss two possible approaches to increase its probative force: sophisticated statistical judgment methods and combining new psychophysiological measures with classic autonomic measures. On the basis of these considerations, we propose several suggestions for future practice and research involving the field CIT.

Keywords: concealed information test, field application, probative force, statistical judgment, combination of measures

Countermeasures to GKT?

- Iacono et al. (1984, 1987) increased incentives and found no effects (relative to placebo) for:
  - Diazepam (widely prescribed tranquilizer)
  - Methylphenidate (stimulant)
  - Meprobamate (tranquilizer)
  - Propranolol (widely prescribed cardiac med. β-blocker that inhibits SNS activity)
- Overall hit-rate for the guilty was >90%

Physical Countermeasures and the CQT

- Honts et al. (1983, 1984)
  - 78% of highly motivated subjects could be trained to "beat" the CQT by biting their tongues or pressing their toes to the floor during control questions
  - Although it took training, motivated suspects could easily obtain it or it could be provided (e.g., antipolygraph.org)
- The polygraphers were unable to detect these subtle maneuvers
- "Counter-countermeasures" worked to detect those using countermeasures: 80% could be detected by a blind analysis of EMG recordings
  - Such counter-countermeasures rarely used in field polygraphy

Physical Countermeasures and the GKT

- The rectangularity score of the GKT should -- in theory -- be much less susceptible to these techniques
  - GKT and rectangularity scores rarely used in field polygraphy
  - Yet Honts et al (1996) found that both Physical (pressing toes to floor) and mental (counting backwards by sevens) countermeasures reduced the validity if the GKT (Overall accuracy dropped from 85% to 25%)

Synopsis

- There is no unequivocal lie response
- Polygraphy:
  - assesses emotional reactions
  - has an unacceptably high false-positive rate
  - Is vulnerable to countermeasures that can reduce true-positive rate
- Polygraphers overestimate accuracy due to how cases are selected for inclusion in studies
- Assessing recognition may prove more accurate, but potentially less widely applicable
- Polygraphs are useful for eliciting admissions and confessions; i.e. "scare the hell out of people"

Science and Pseudo-Science, Debate and Diatribe, Validity versus Vitriol

If I announce to my scientific colleagues that I have invented a new test that can identify schizophrenia with 90% or 95% accuracy, my colleagues will be interested -- but skeptical. I would be expected to support my assertion with experimental evidence and that evidence would be very critically examined. Even if my proofs withstood such scrutiny, many would reserve judgment until an independent investigator had confirmed my findings. All this skepticism about a claim that I can distinguish "crazy people" from normal ones! The tools of the psychologist are not precision instruments; really high accuracy is seldom achieved. Skepticism is appropriate. Nevertheless, when the polygrapher announces that his psychological test can separate liars from the truthful with a validity of 90%, or 95%, or even 99%, the typical reaction is a kind of marveling acceptance. The critic who questions these claims is greeted with surprise and skepticism. Nearly every American has heard of the lie detector; without really knowing what is involved, many assume that it is nearly infallible. So deeply ingrained is this mystique that, gradually over the last 50 years, the burden of proof has somehow shifted to the critic.

Lykken, in *A Tremor in the Blood*, 1981

Science and Pseudo-Science, Debate and Diatribe, Validity versus Vitriol

Unfortunately, the minute a small handful of psychologists -- one or two pseudo-knowledgeable and one or two completely ignorant of what they were even trying to do -- got into the picture, two expressions, "false positive" and "false negative", came to light. It appears that some people turn out to be weird ducks. Sadly, when that type of inquirer doesn't understand something, he is usually prone to attach strange names to it under the guise of professionalism or scientific exploration on both sides of the same coin. By confusing other people more so than himself he feels he can still call himself an "expert." Those two phrases appeared in a tumor in the brain [sic]. Before then, they had never existed in polygraph language. In all sincerely, however, foul ball psychologists are few and far between.

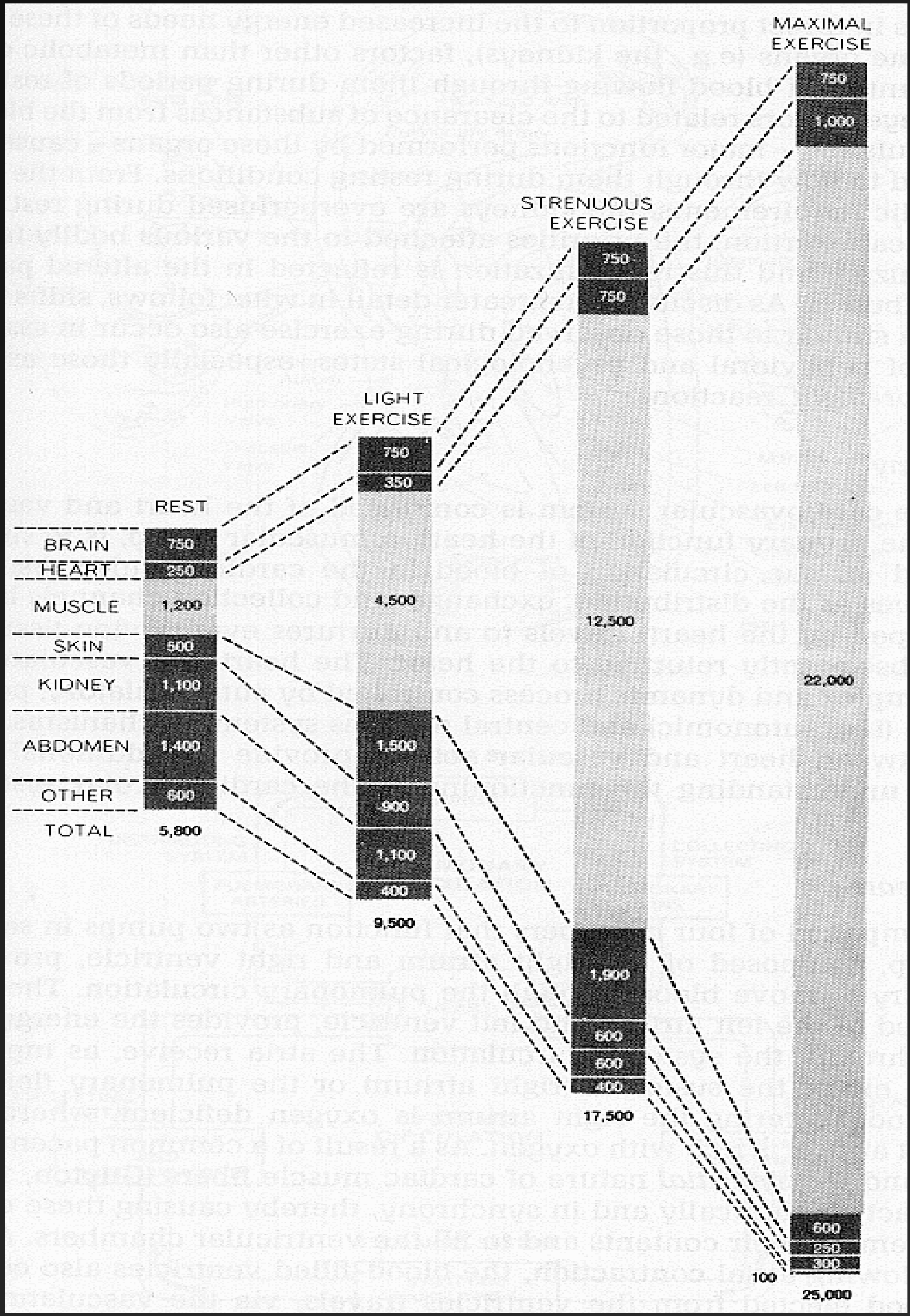
Ferguson, in *Preemployment Polygraphy*, 1984

Cardiovascular Psychophysiology

Facts and Functions

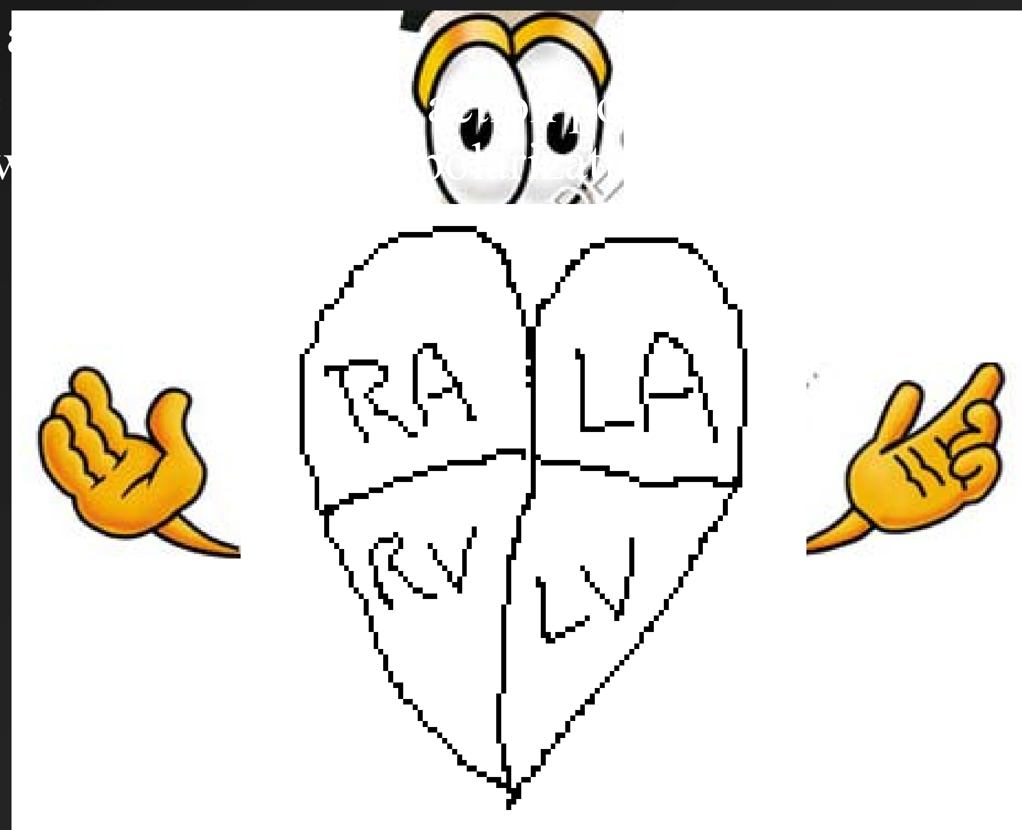
- The busy heart
  - Six quarts of blood pumped per minute
  - 100,000 beats per day
  - Try it!
- Functions
  - Transport oxygen from lungs and nutrients from gut
  - Transport waste products
  - Transport regulatory substances (e.g. endocrines)
  - Thermal exchange between core and periphery

Metabolic Demands



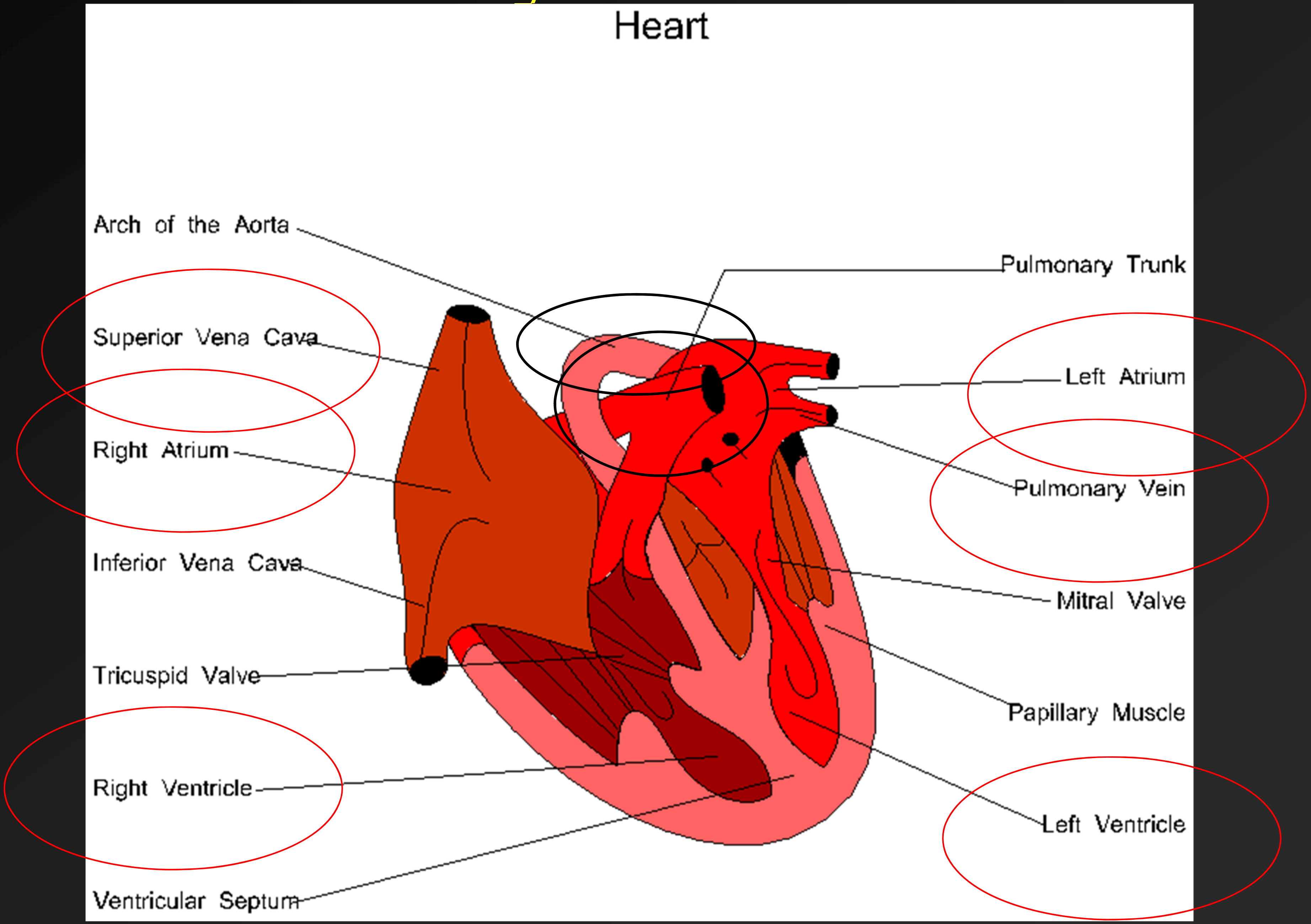
Anatomy of the Heart

- Cardiac Muscle (myocardium)
  - not striated, not smooth
  - four features distinguish from smooth or striate
    - Muscle has unstable resting potential – basis for intrinsic and rhythmic contraction
    - Action potential freely conducted from one cell to another (lattice-like syncytial) network of cardiac fibers
    - Repolarization lasts
    - Contraction phase = depolarization follow secs)

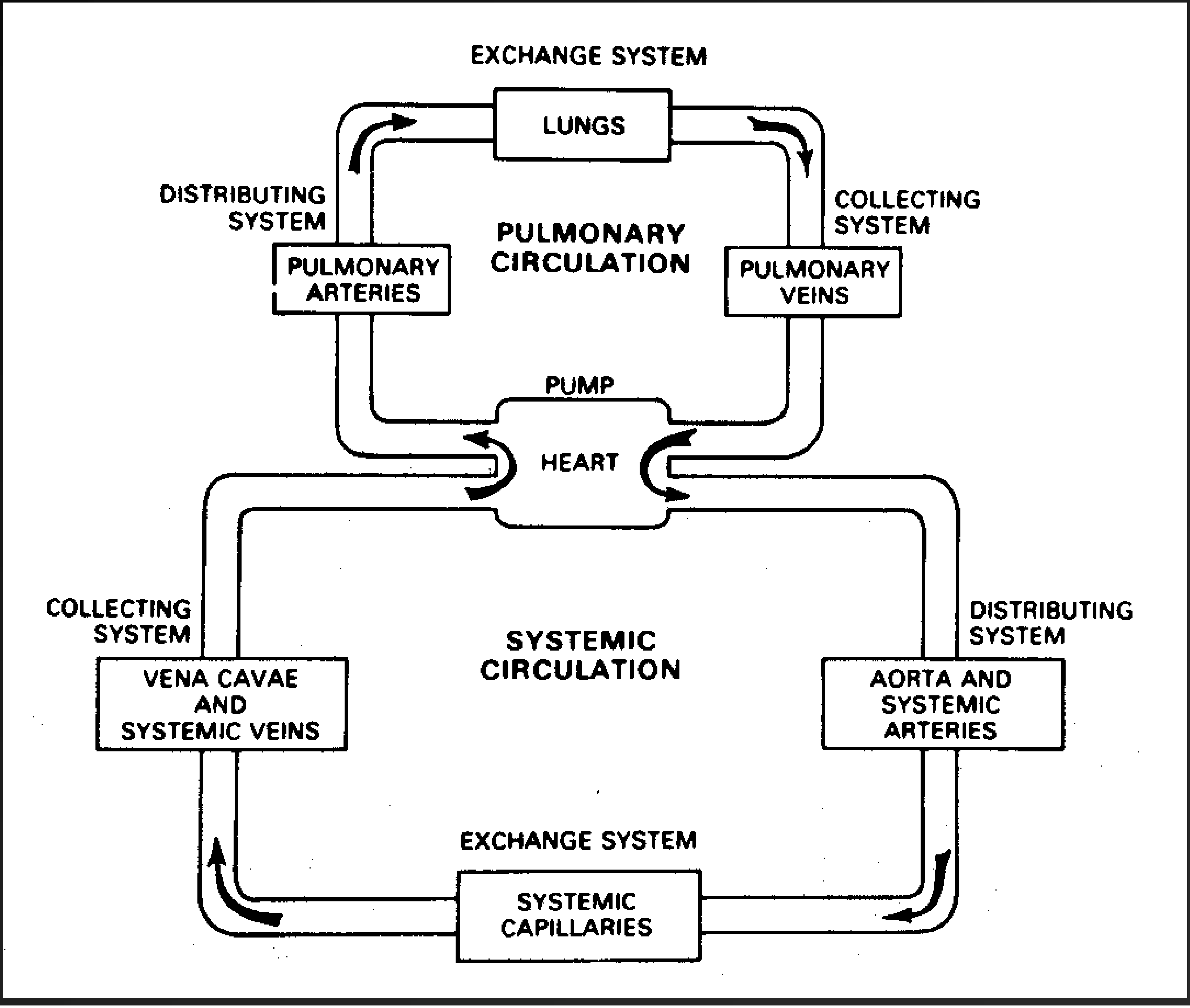


- Four chambers
  - Right Atrium
  - Right Ventricle
  - Left Atrium
  - Left Ventricle

Anatomy of the Heart



Human Circulatory System



Circulation in a bit more realistic detail

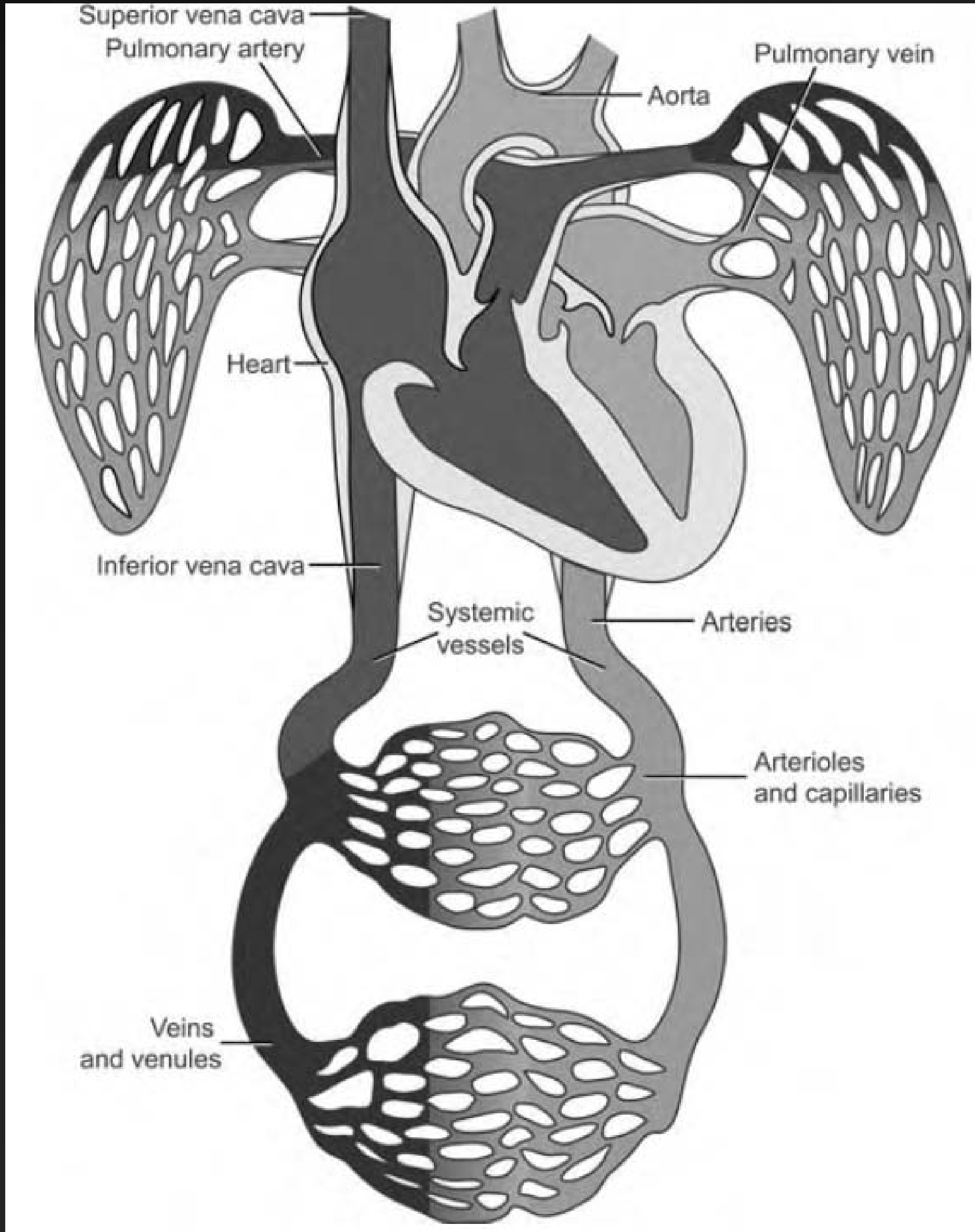
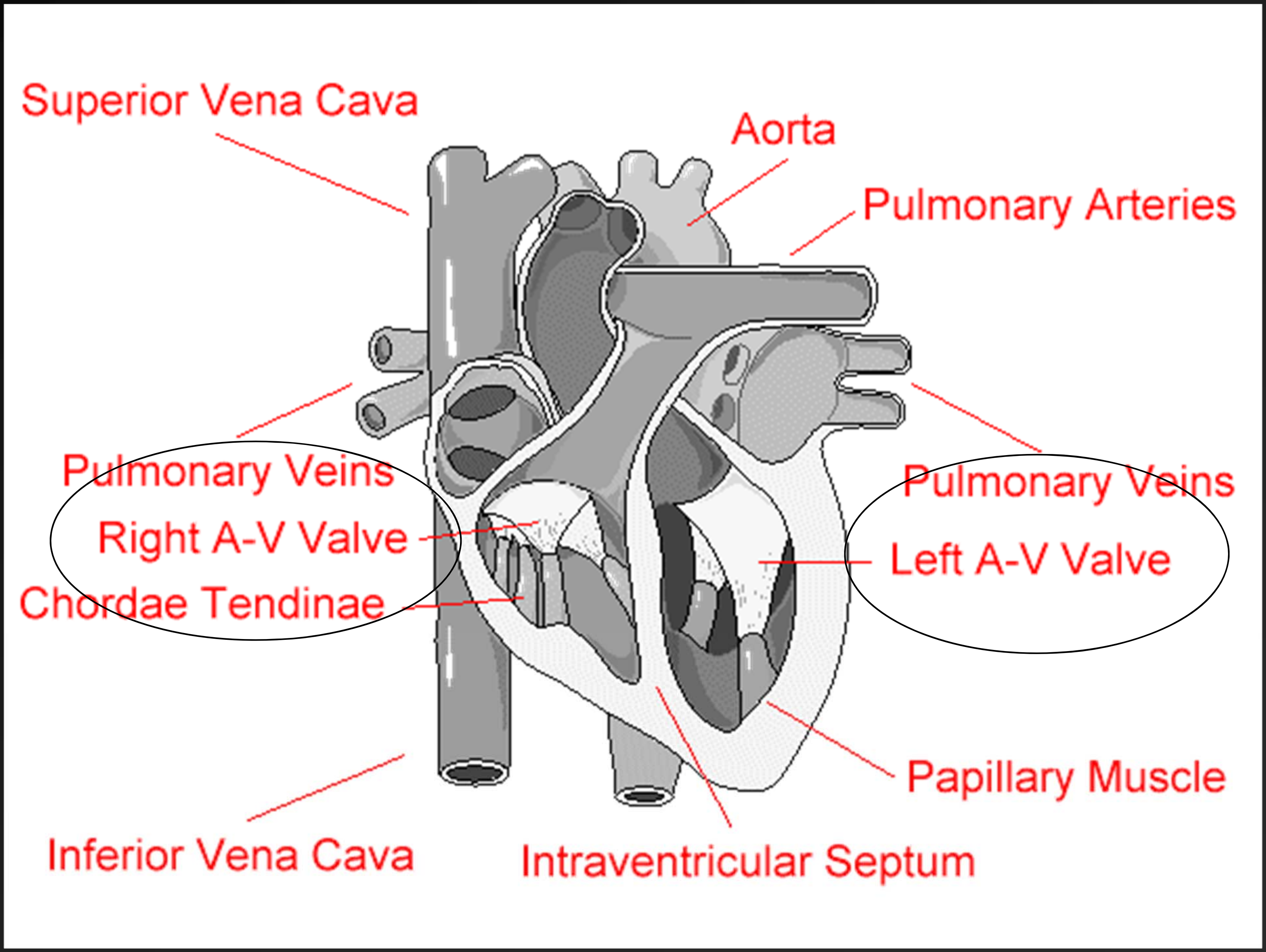


Figure 8.1. Systemic and pulmonary circulation. In keeping with usual depictions of the heart, the right side of the heart is on the left side of the picture. Lighter gray areas indicate oxygenated blood and darker gray areas indicate deoxygenated blood.

Anatomy of the Heart



More Valves

- Aortic and Pulmonary Valves
  - Respond to relative pressure difference between ventricles and aorta or pulmonary artery
  - As ventricles contract, pressure builds, and forces valves open when pressure exceeds arterial pressure
- "Dub" in the Lub-Dub sound (sounds are valves closing or "slamming" shut)

Neural Conduction of the Heart

- Two Nodes
  - Sino-Atrial (SA) node – “Primary Pacemaker”
  - Atrial-Ventricular (AV) node – “Yoked”

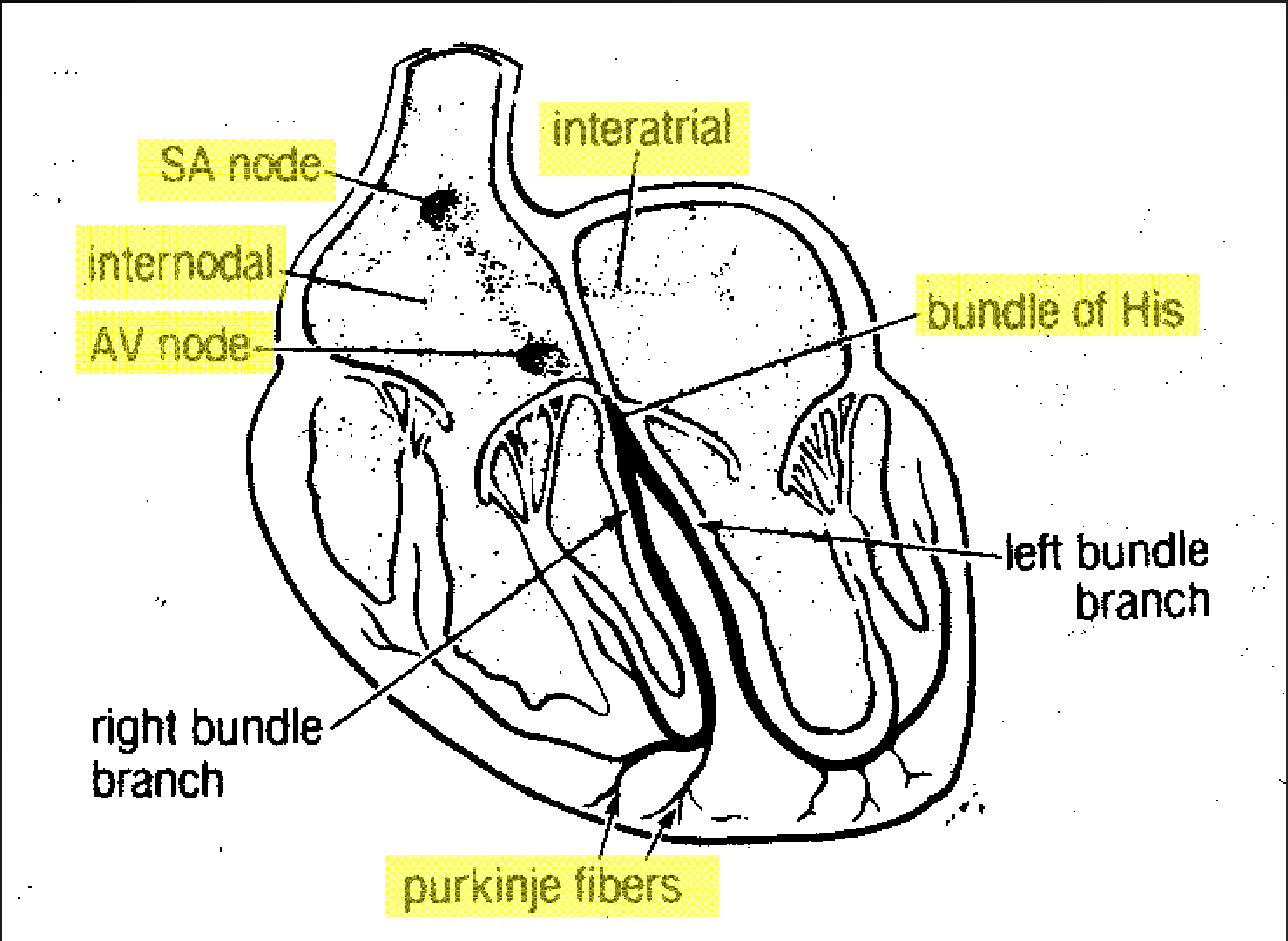
- Nodes have intrinsic rythmicity
  - SA node: 105 bpm
  - AV node: 40-60 bpm

- Denervated heart would still beat at over 100 bpm
  - Must be extrinsic influences to slow or speed heart

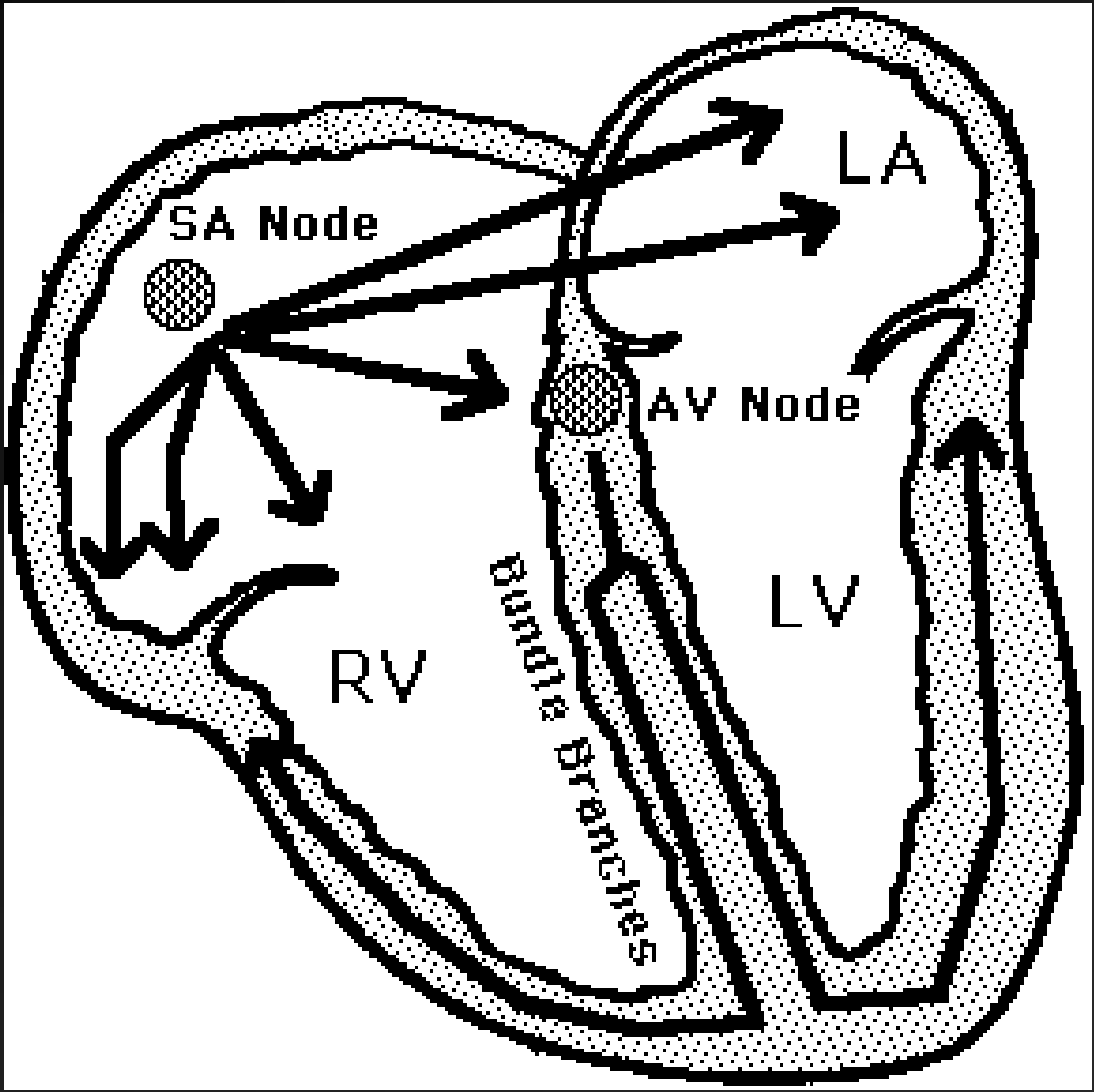
Neural Conduction of the Heart

- Hierarchy ensures that normally the SA node "drives" the system
  - AV nodes provide a critical delay (allows atria to fully contract before ventricles do)
  - AV nodes have important refractory period to prevent rapid successive ventricular contractions
- A coordinated wave of depolarization
  - Contraction of 4 chambers of heart must be precisely choreographed

Nodes and Fibers

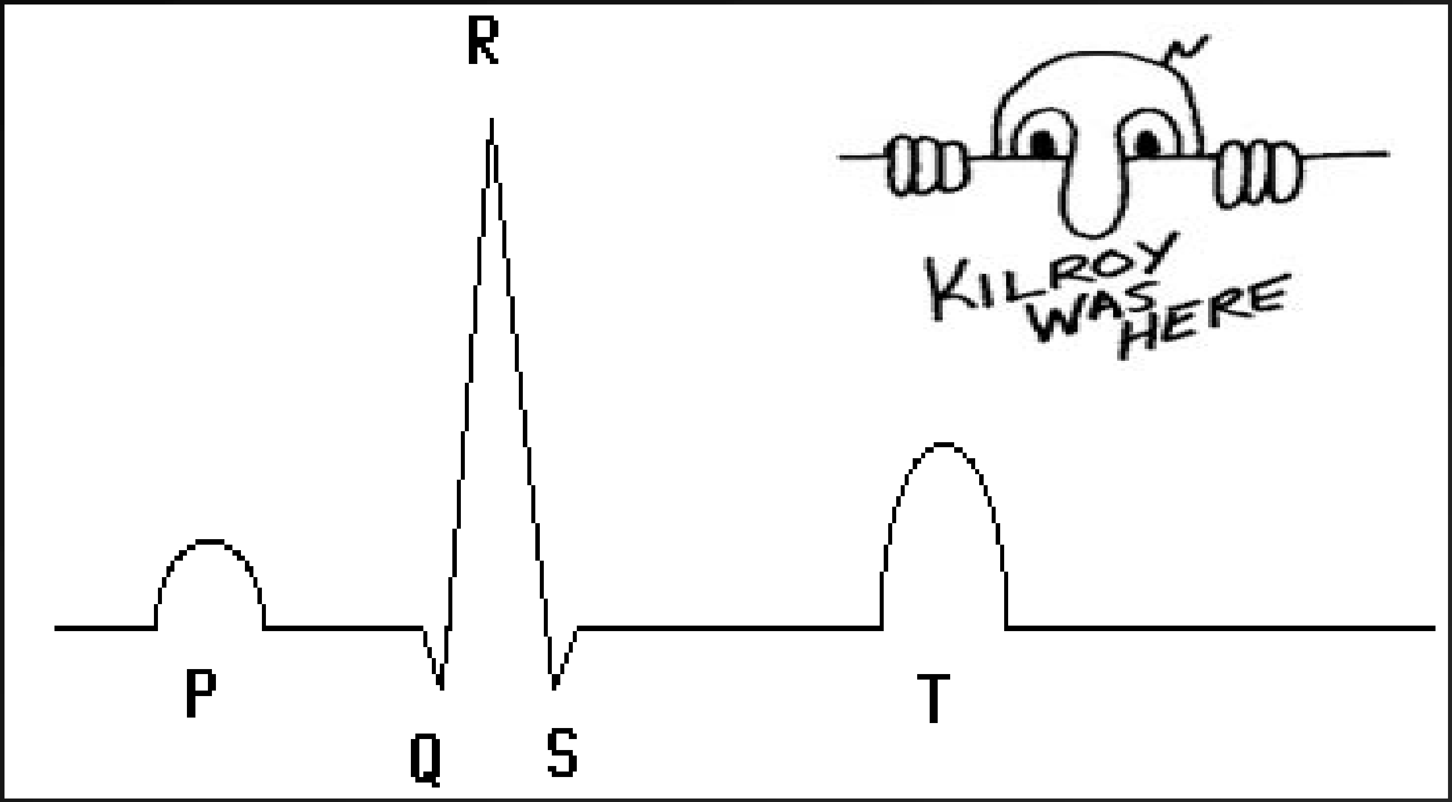


The SA and AV Nodes in Action



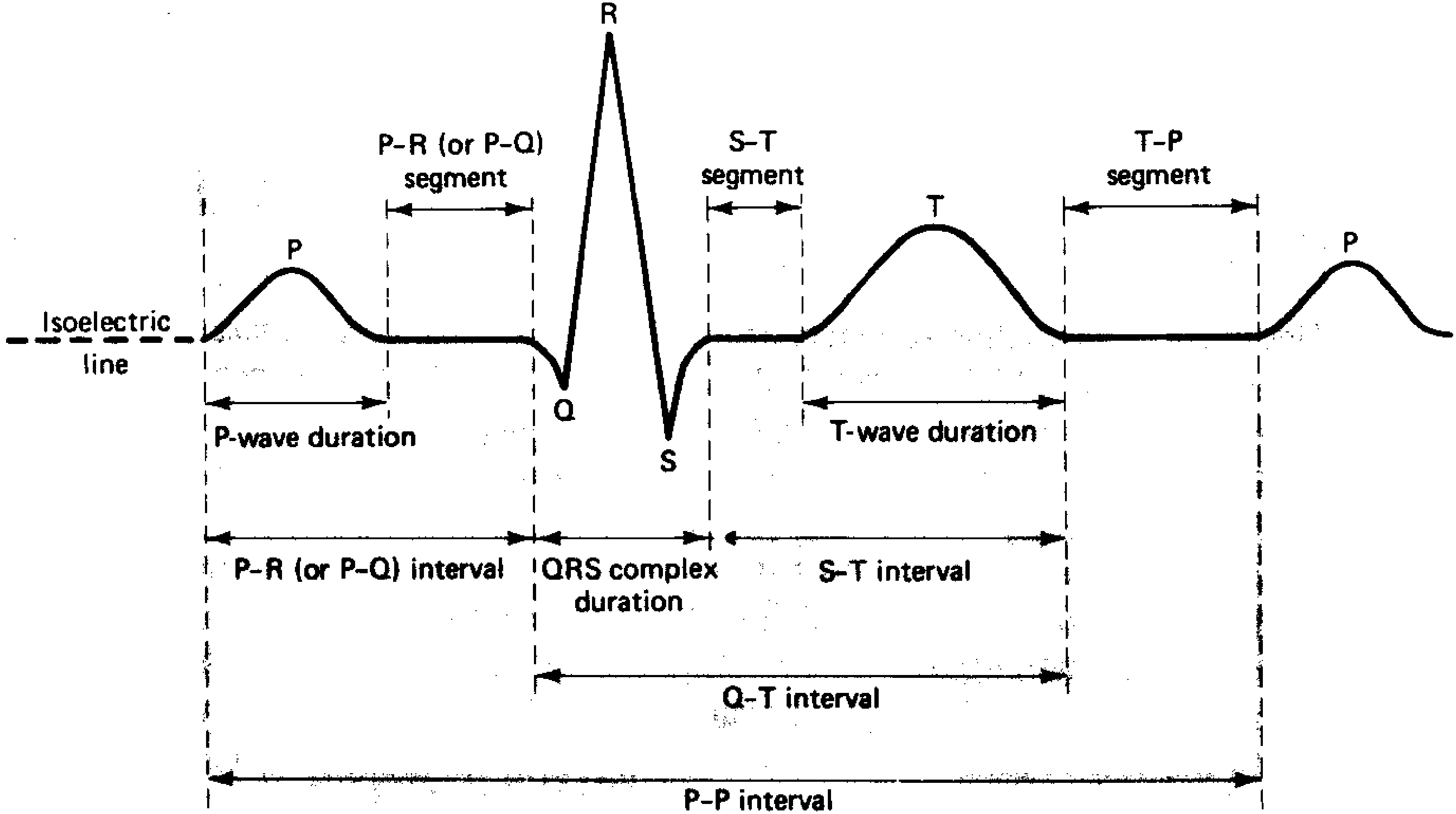
Important: refractory period of the AV node is longer then the time it takes the ventricles to contract

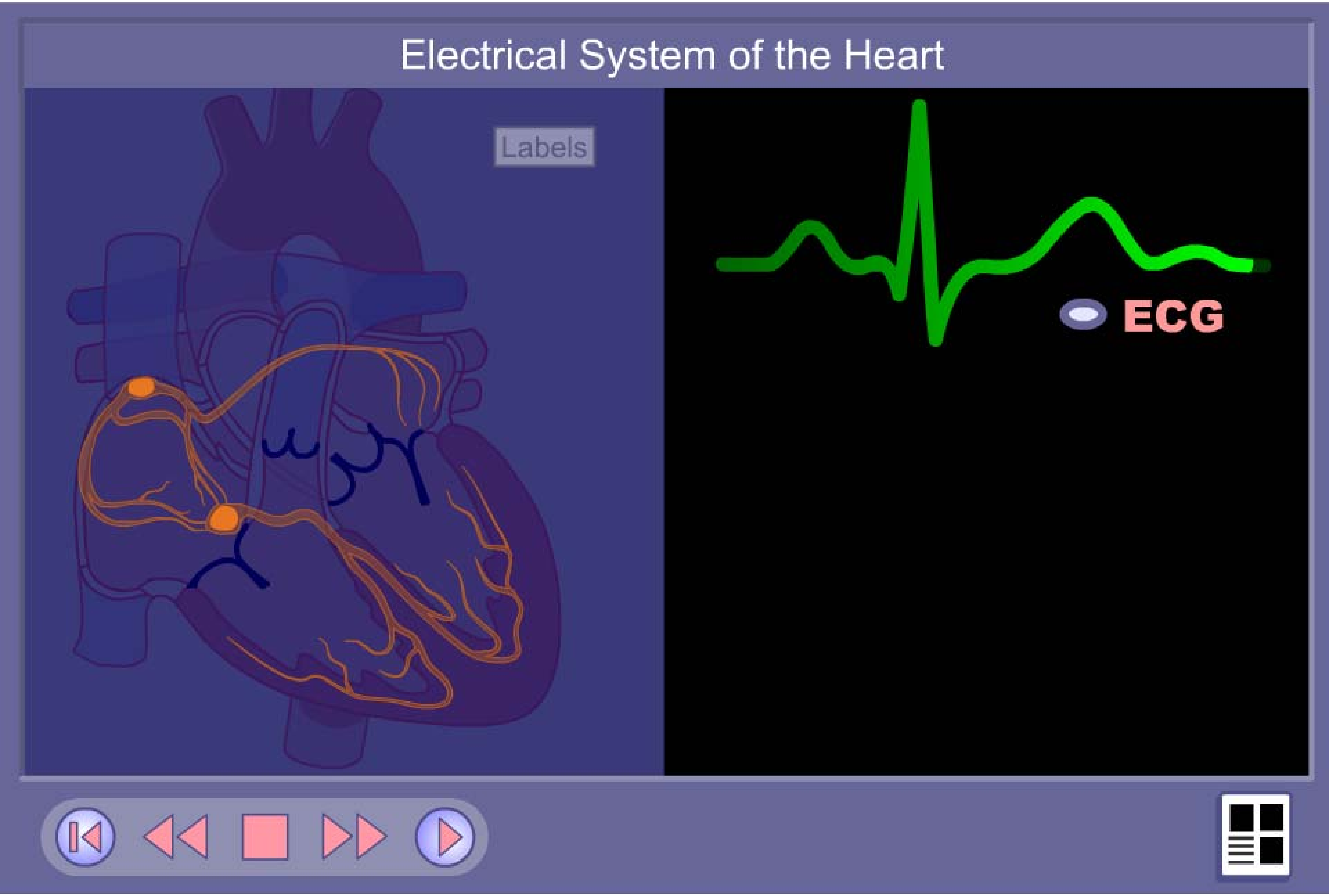
The Schematized EKG waveform



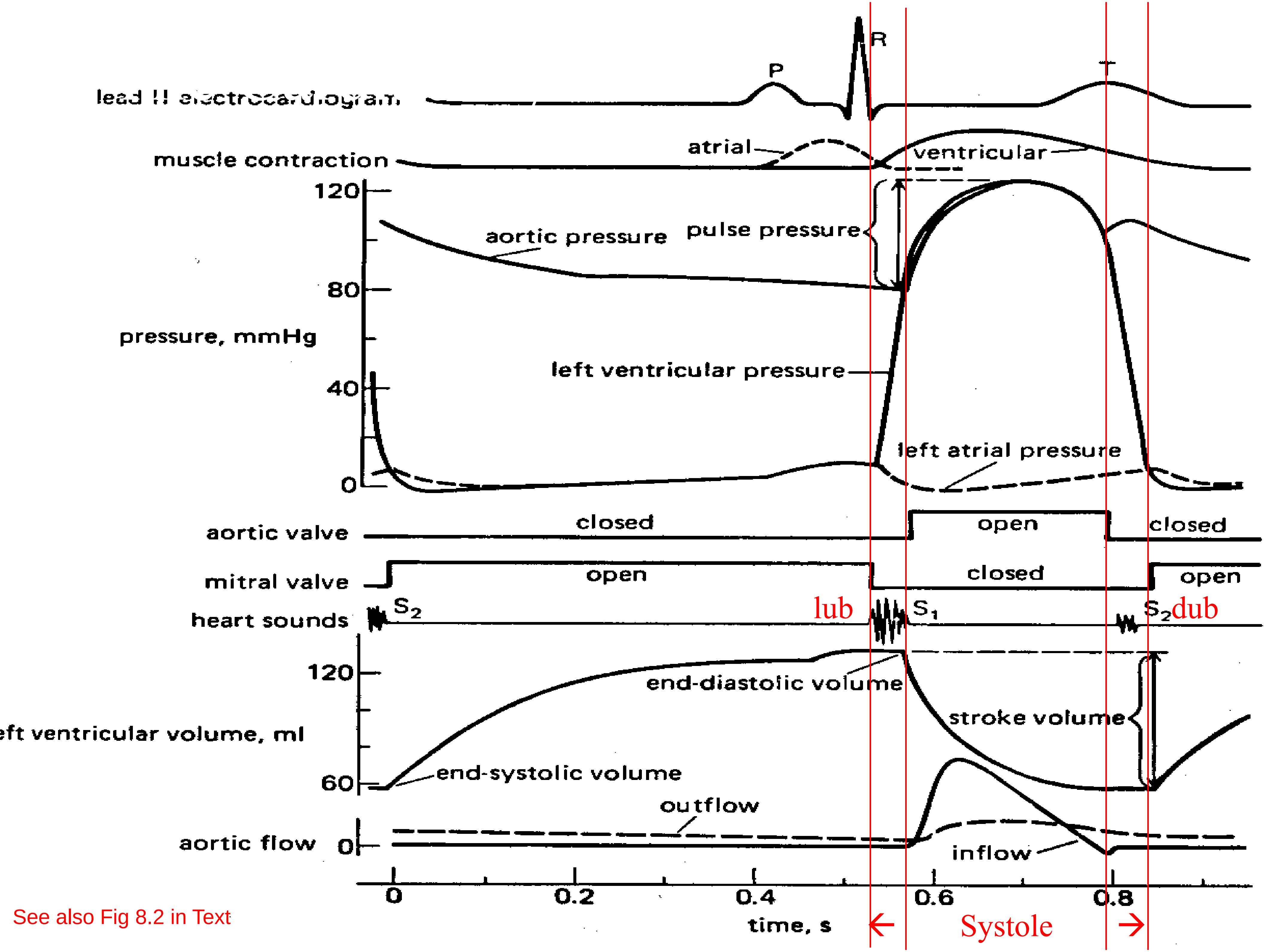
P = Atrial depolarization
QRS = Ventricular depolarization
T = Ventricular repolarization
Note that Atrial repolarization is not visible

The EKG waveform

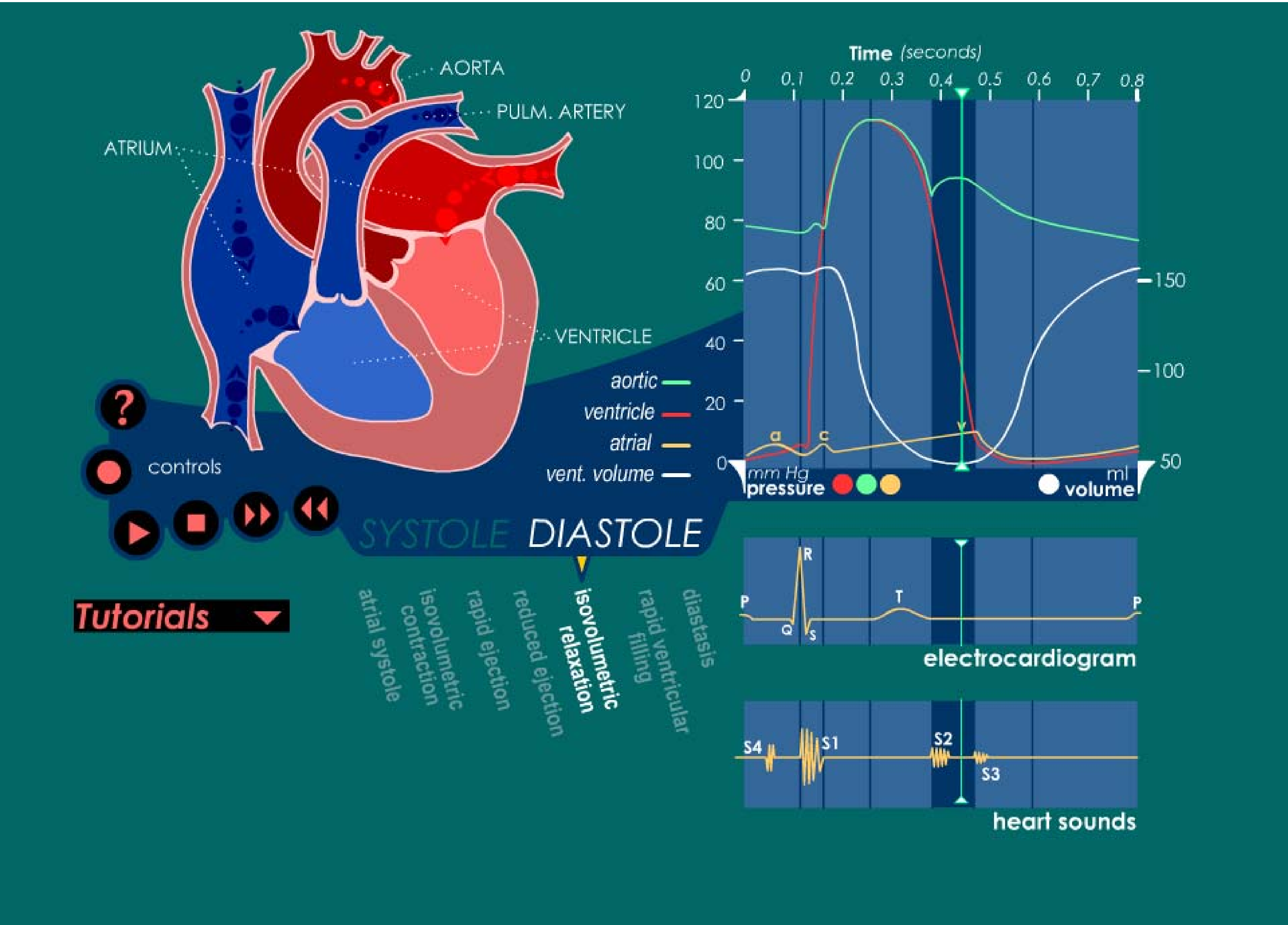




http://mcdb.colorado.edu/courses/2115/units/Other/heartbeat%20animation.html



See also Fig 8.2 in Text



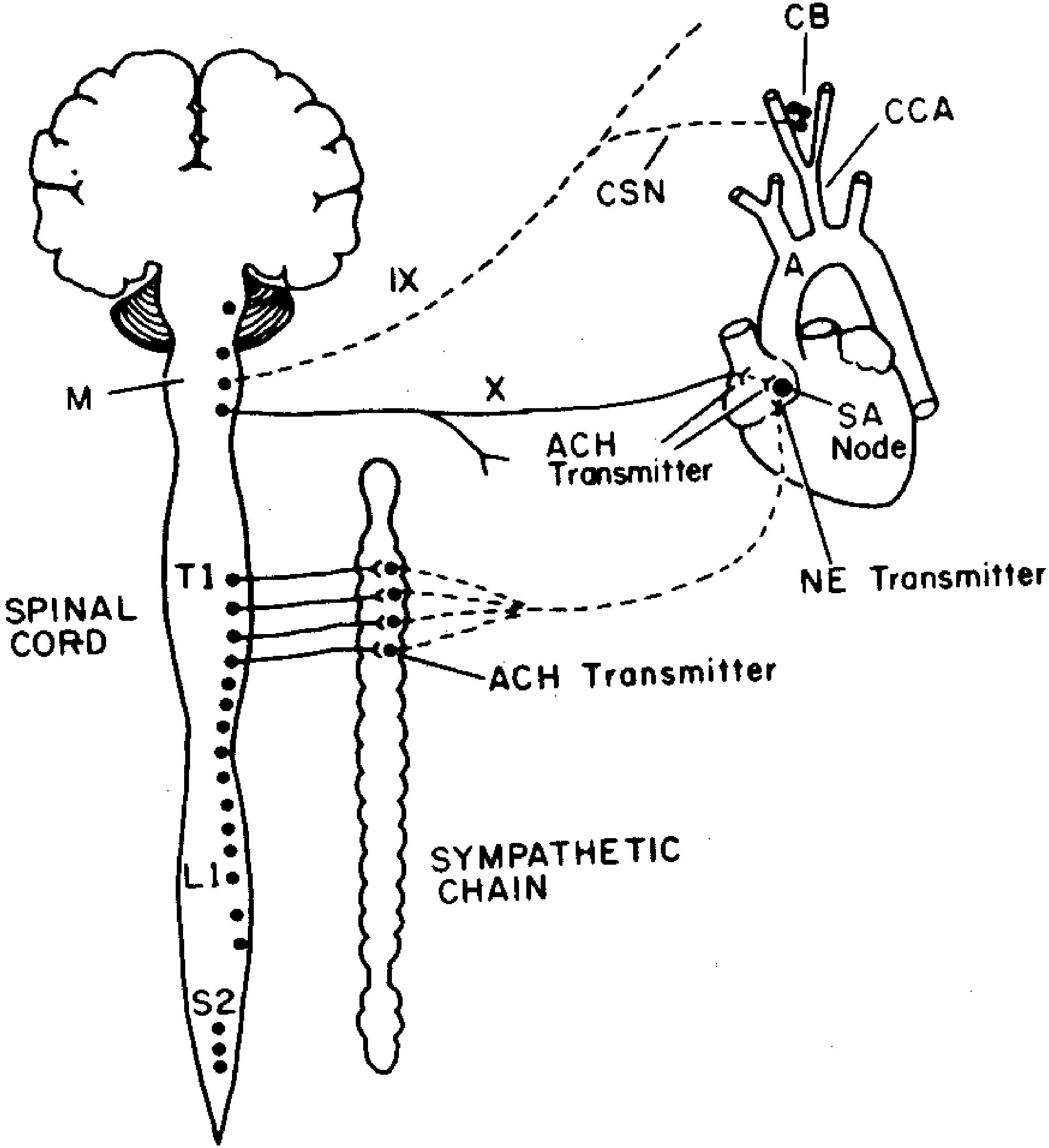
http://www-medlib.med.utah.edu/kw/pharm/hyper_heart1.html

Cardiac Output

$$CO = HRxSV$$

Cardiac Chronoptropy

- Heart rate regulated extrinsically
- Vagal (PNS) influence
  - Slows HR
  - So too will dripping ACH on SA node
  - Likely that all changes below 100 bpm are predominately vagally induced
- SNS influence
  - Speeds HR, but impact not as strong as PNS
  - Main effect is to increase contractility


CB
CCA
CSN
IX
A
M
X
SA
Node
ACH
Transmitter
T1
SPINAL
CORD
NE Transmitter
ACH Transmitter
L1
SYMPATHETIC
CHAIN
S2

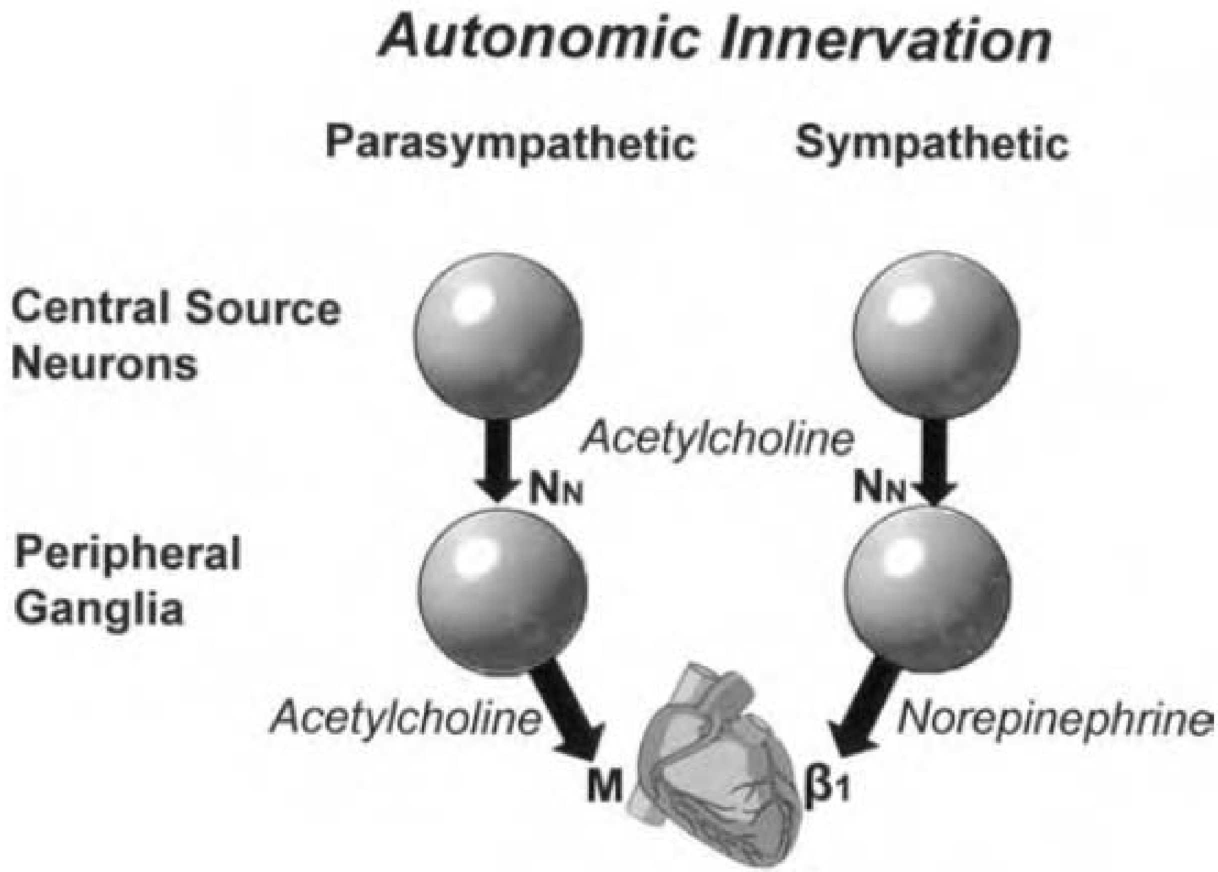
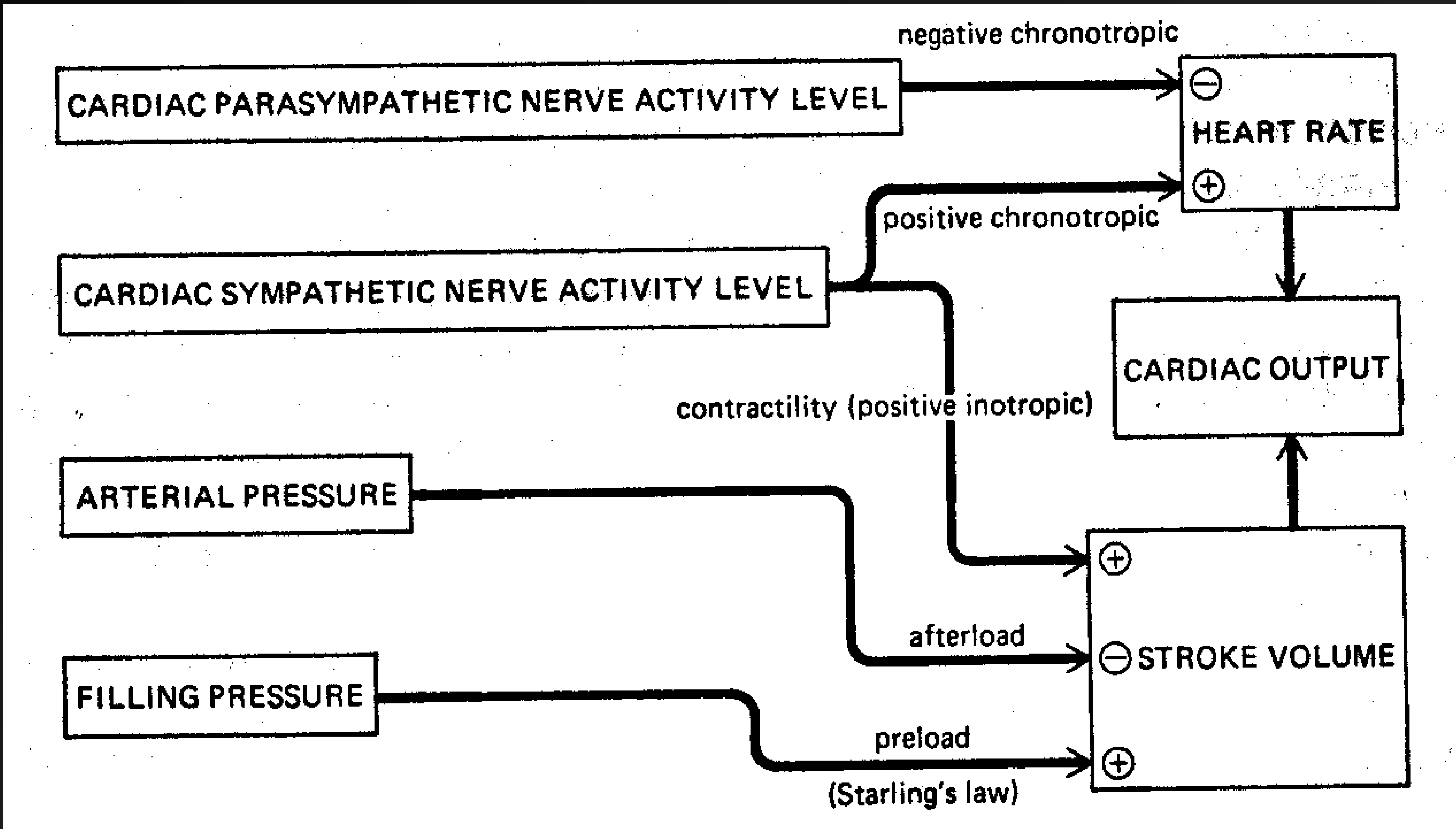
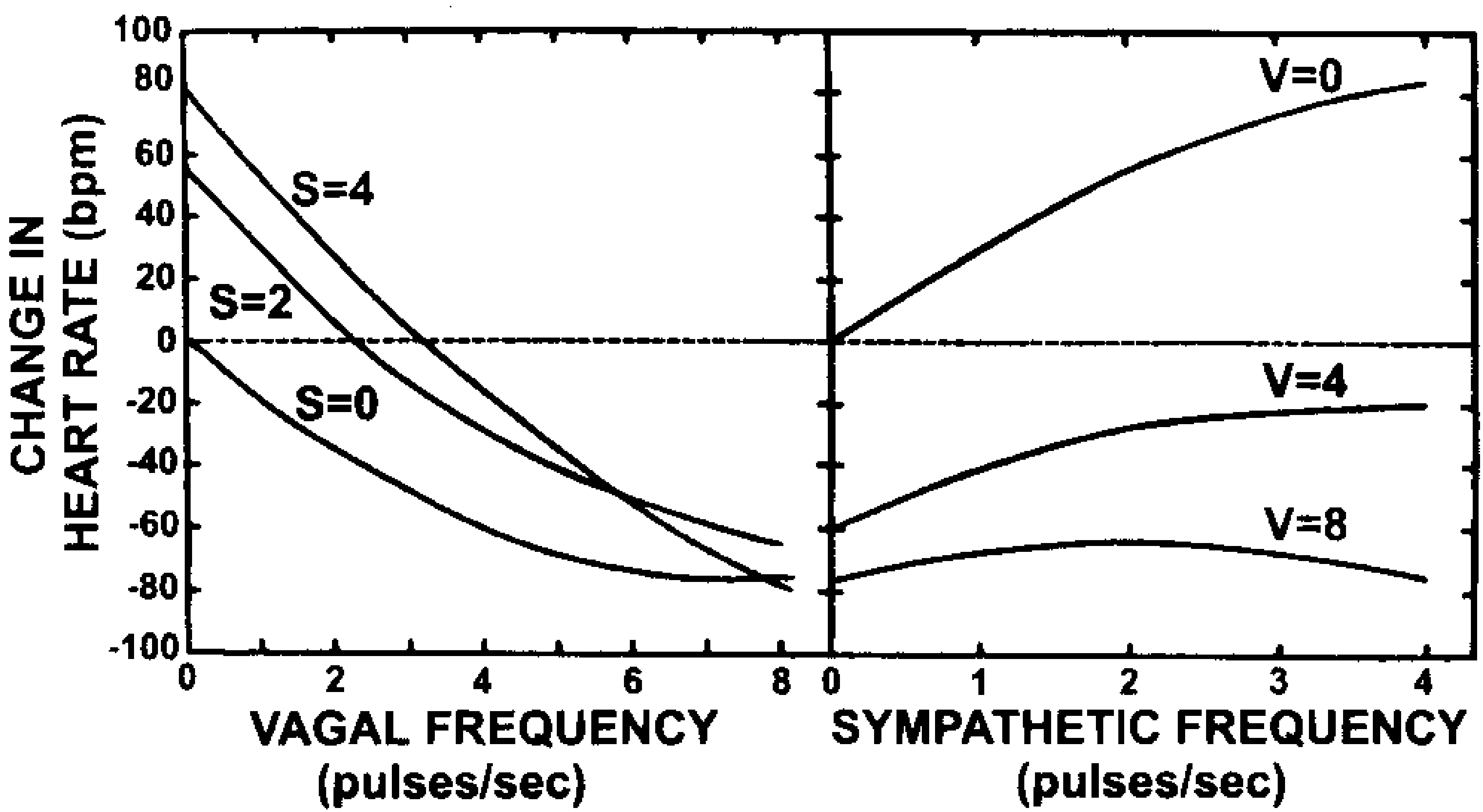


Figure 8.6. General pattern of pharmacology of the autonomic innervations. Abbreviations refer to the relevant postsynaptic receptor populations: N_N – nicotinic cholinergic; M – muscarinic cholinergic; $\beta 1$ – beta1 adrenergic.

SNS and PNS influences



HR change to simultaneous vagal and sympathetic stimulation



Levy & Zieske (1969). *J Applied Phsyio*, *27*, 465-470

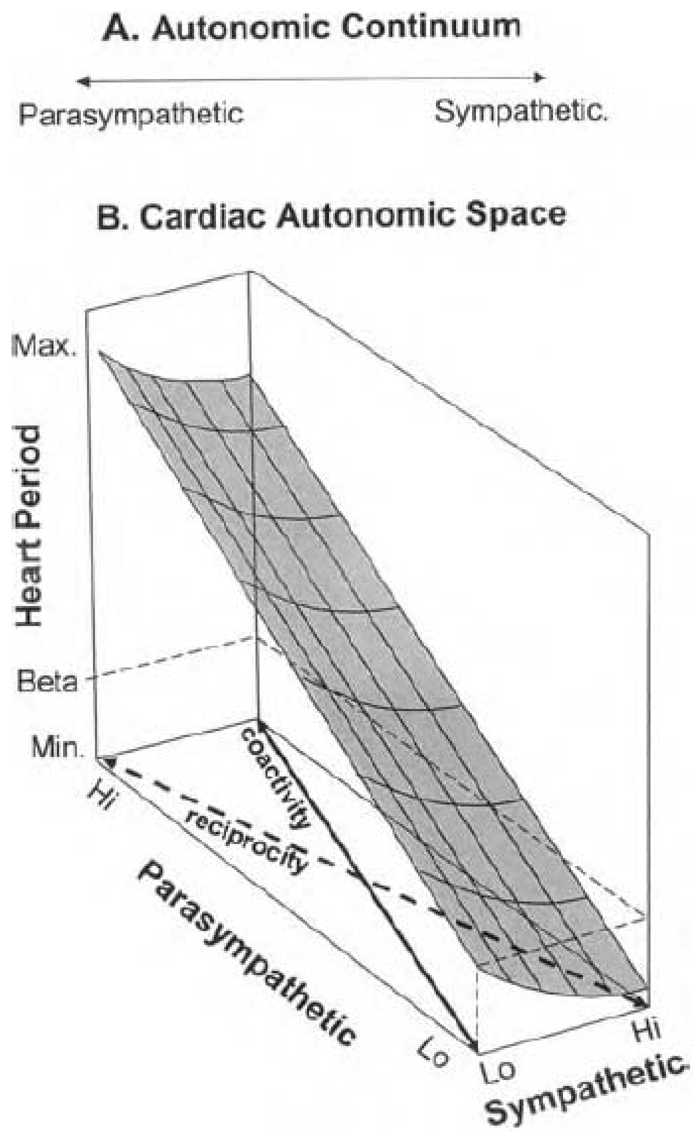


Figure 8.9. Autonomic space. (A) Continuum model of autonomic control, wherein the status of the system can be depicted along a single continuum extending from parasympathetic dominance to sympathetic dominance. (B) A more comprehensive model of autonomic control, characterized by an autonomic plane (representing the fact that parasympathetic and sympathetic systems can change reciprocally, coactively, or independently) and an overlying effector surface which illustrates the end organ state (heart period) for any location on the underlying autonomic plane. Beta illustrates the intrinsic heart period in the absence of autonomic control.

Integrated Control Mechanisms

- Baroreceptor Reflex
  - Pressure sensitive receptors
  - located in the arch of the aorta and carotid sinus nerves
  - Join Vagal and Glossopharangeal nerves
  - Terminate in regulatory centers in medulla
  - With increase in BP, causes compensatory decrease in HR, contractility, and SV
  - Quickly adjusts to maintain BP
- Valsalva Maneuver

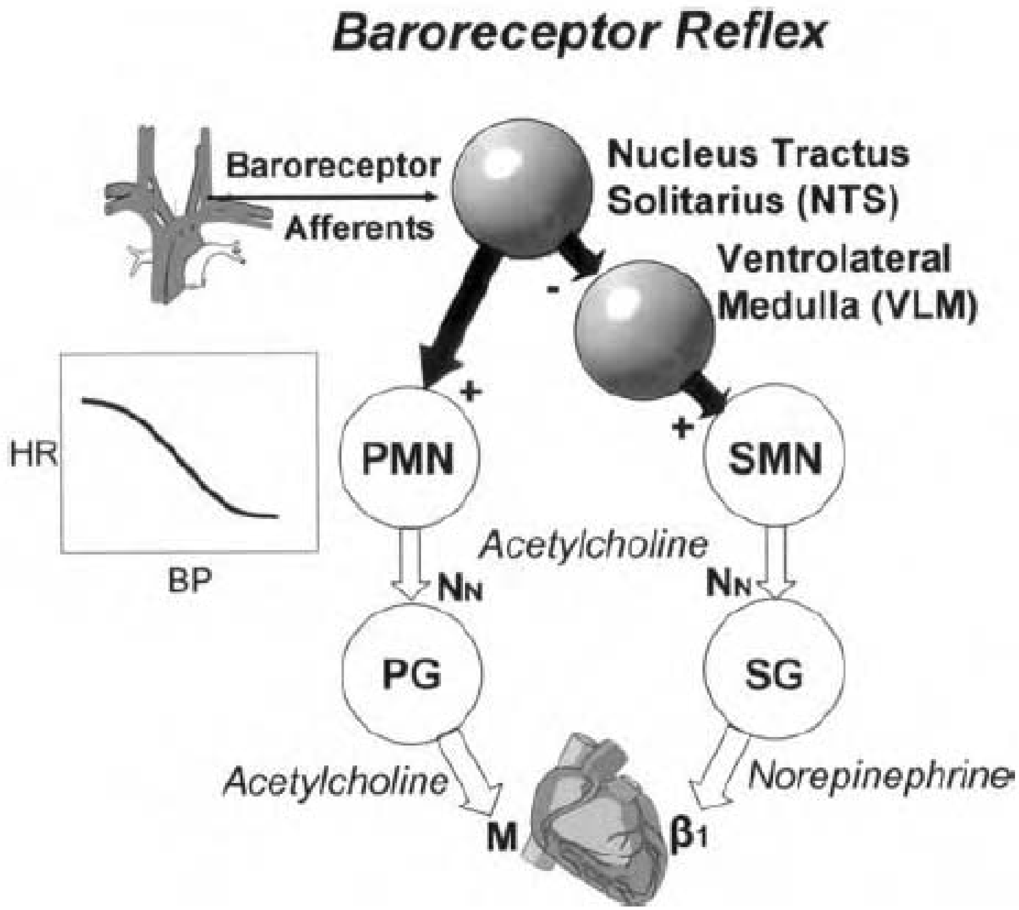
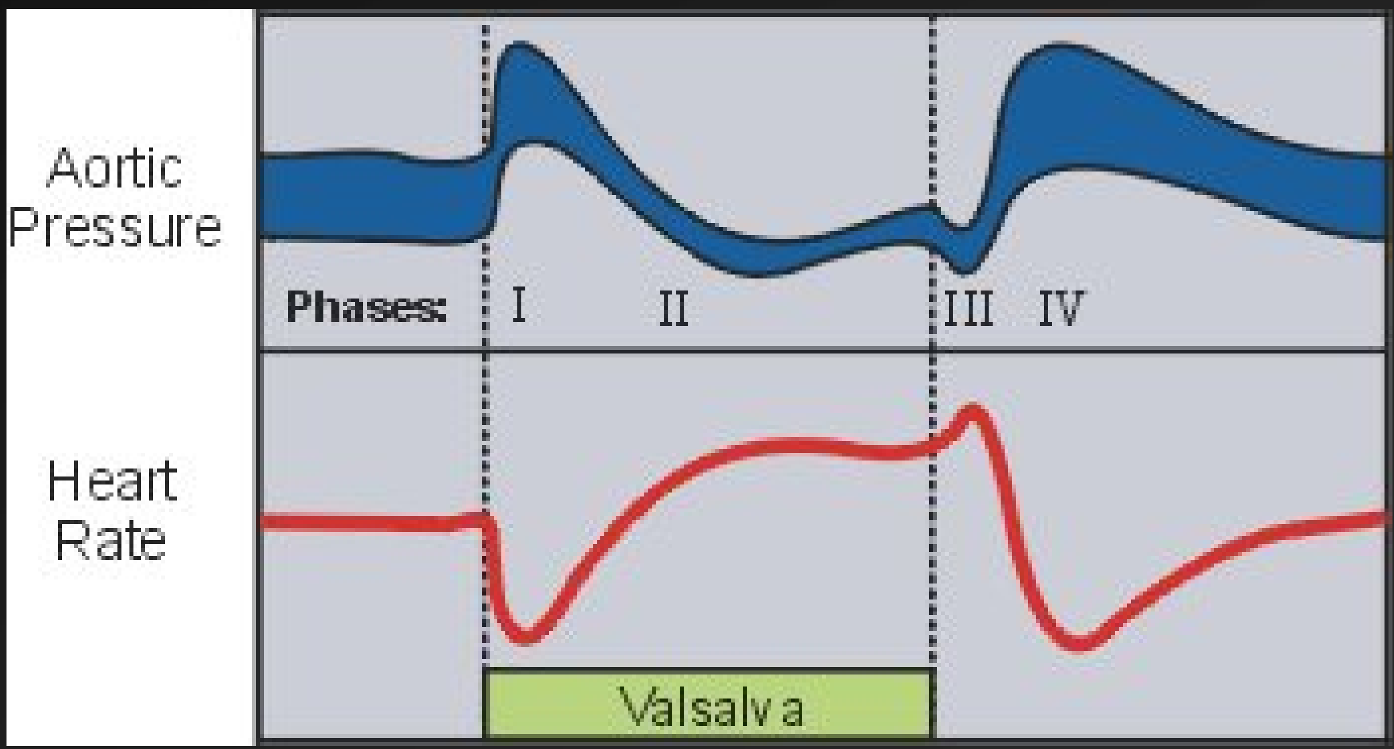


Figure 8.7. General organization of the baroreceptor heart rate reflex. Reflex originates in mechanoreceptors in the heart and the carotid and other great arteries. The NTS excites (+ symbol) the parasympathetic motor neurons (PMN) and inhibits (– symbol) relay neurons to the sympathetic motor neuron pool (SMN). Insert illustrates the relationship between blood pressure (BP) and heart rate (HR). PG and SG depict parasympathetic and sympathetic ganglia, respectively. Other abbreviations are as in Figure 8.6.

Valsalva Maneuver



Integrated Control Mechanisms

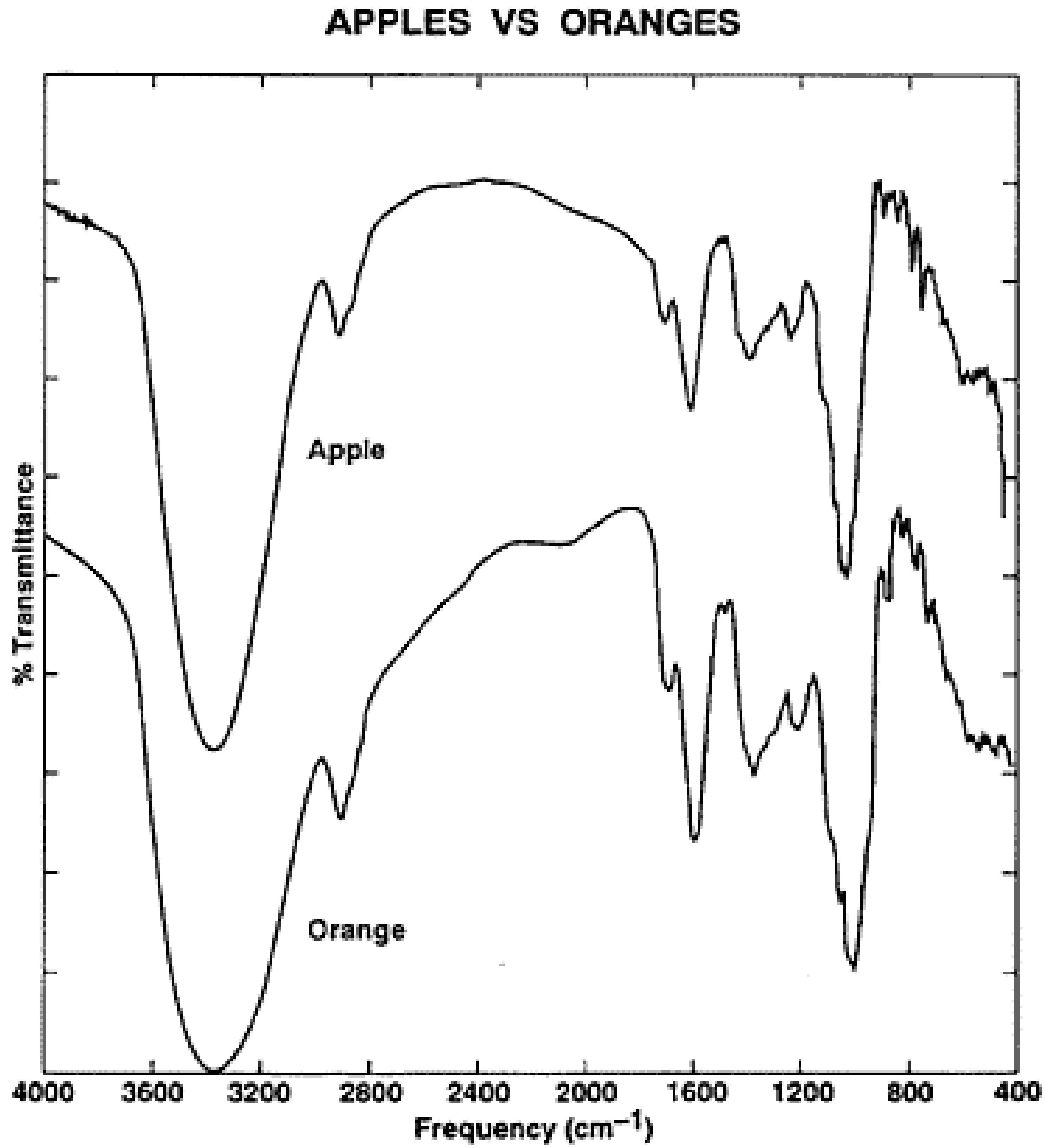
- Respiratory Effects
  - Respiratory Sinus Arrhythmia (RSA)
    - This arrhythmia is not a bad thing!
  - HR acceleration linked to inspiration
  - HR deceleration linked to expiration
- RSA
  - Indexes strength of Vagal influence
  - More later…

Cardiac Inotropy

- Contractility is predominately Sympathetically mediated
- Often measured invasively, but can be measured noninvasively
  - EKG plus phonocardiogram
  - Impedance cardiography

SNS and PNS Integration: A Caveat

- Relatively easy to measure PNS: RSA or other metrics of HRV
- Relatively easy to measure SNS: Contractility via PEP
- BUT… one is measure of chronotropy, other is measure of inotropy
  - Changes in contractility can occur independently of changes in rate
  - SNS inputs for inotropy primarily controlled by left-sided inputs to AV node
  - SNS inputs of chronotropy primarily controlled by right-sided inputs to SA node
- Thus, like "mixing apples and oranges"



Comparison of the 2.5-25 mm infrared transmission spectra of a Granny Smith apple and a Sunkist Navel orange.

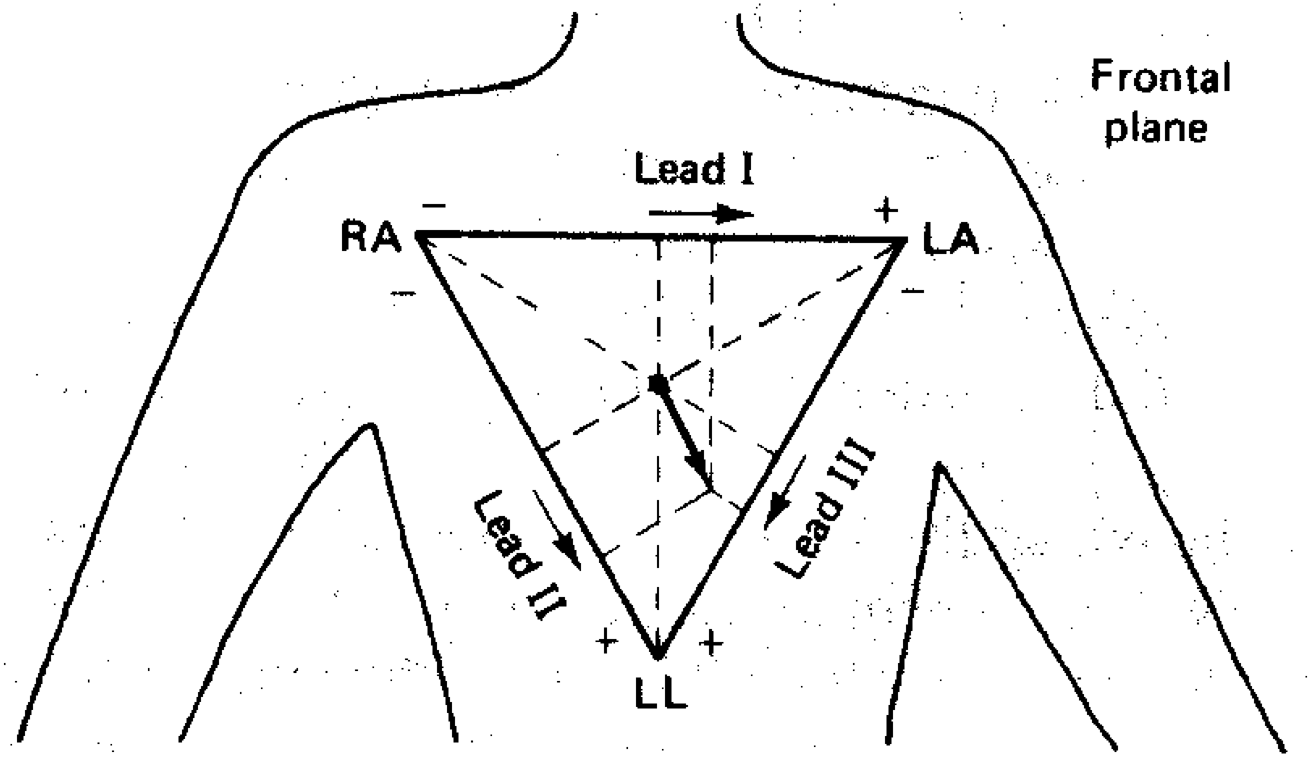
Source: *Biomednet.com*

Cardiovascular Measures

- Electrocardiogram (EKG)
- Phonocardiogram (PCG)
- Impedance cardiography
- Photoplethysmography
- Ballistocardiography
- Blood Pressure

EKG

AC signal
Sample 200-500 Hz

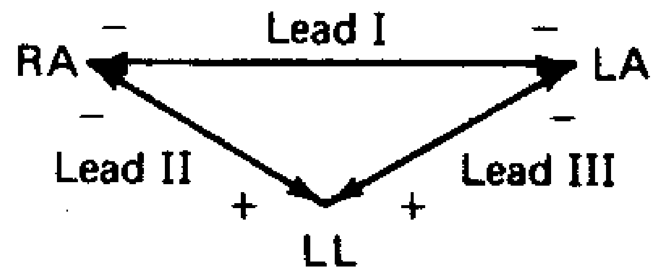


Bipolar

Bipolar limb leads: ECG voltage measurements between pairs of limbs:

Lead I:	between RA and LA
Lead II:	between RA and LL
Lead III:	between LA and LL

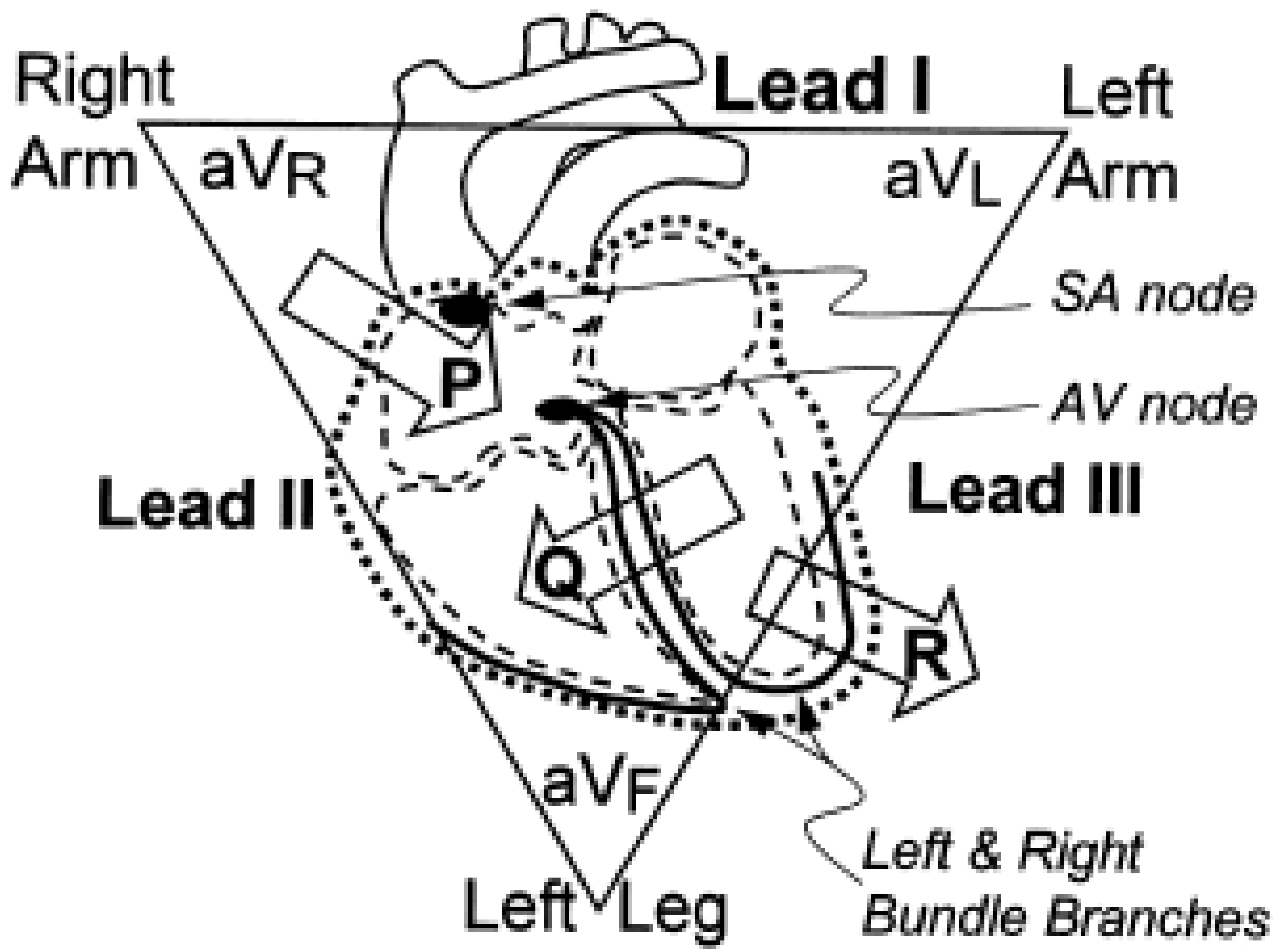
Einthoven triangle, showing relation of the bipolar limb leads



EKG

AC signal
Sample 200-500 Hz

B. Einthoven's triangle



EKG Demo

Which Time?

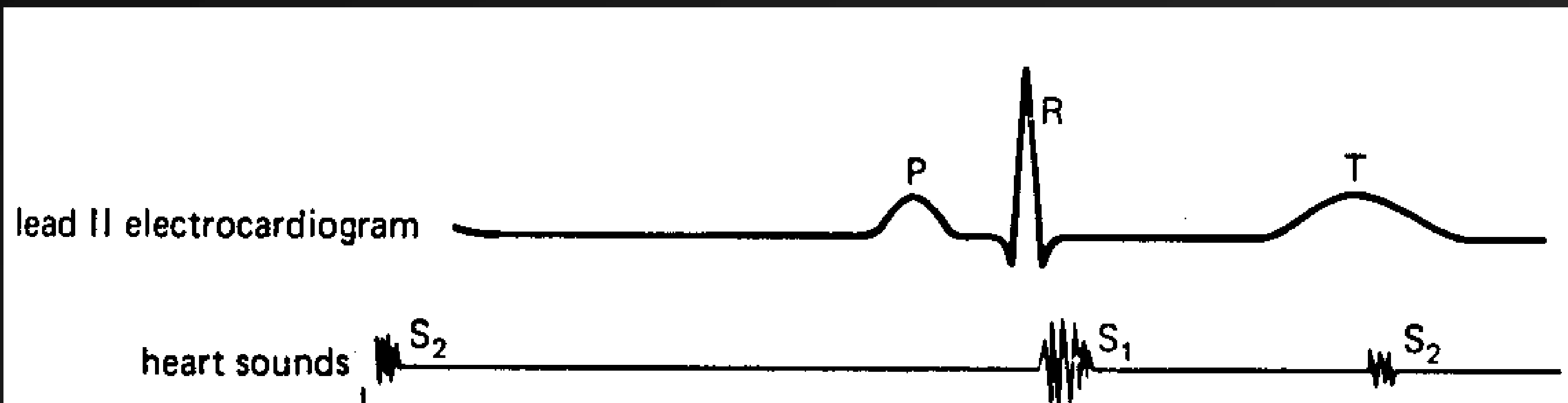
- Real time
  - Heart Rate
  - Expressed as beats per time (usually bpm)
- Cardiac time
  - Heart Period; interbeat interval (IBI)
  - Expressed in msec
- Converting

$$HR = \frac{1}{HP} x60{,}000$$

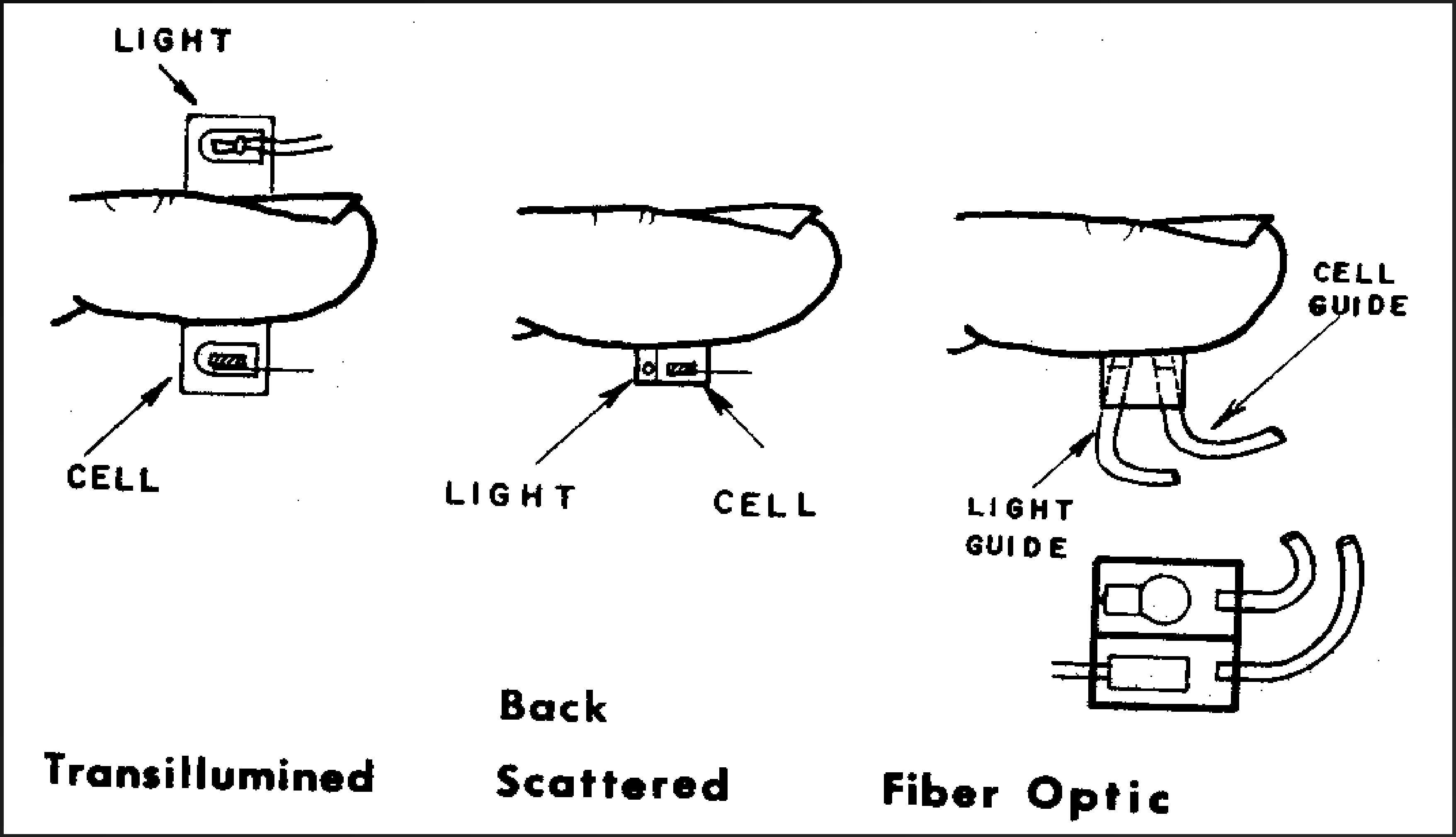
$$HR = \frac{1}{1000} X\,60{,}000 = 60bpm$$

Phonocardiography

- Position microphone over heart
- Lub-Dub is transduced to electrical signal

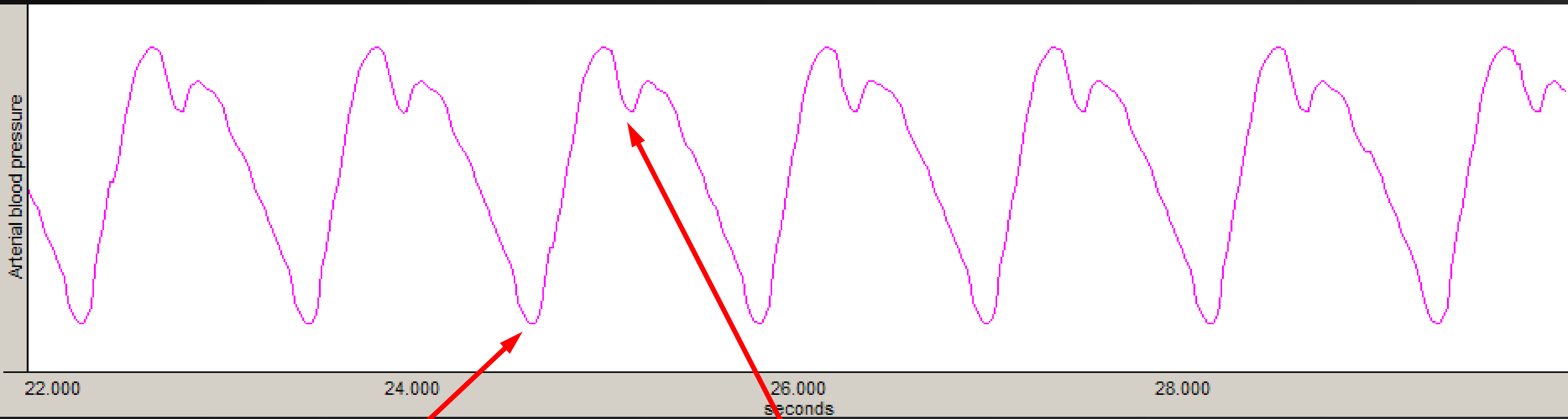


Photoplethysmography



Three methods, all involve measuring light absorbed by peripheral vasulature

The Photoplethysmographic Output

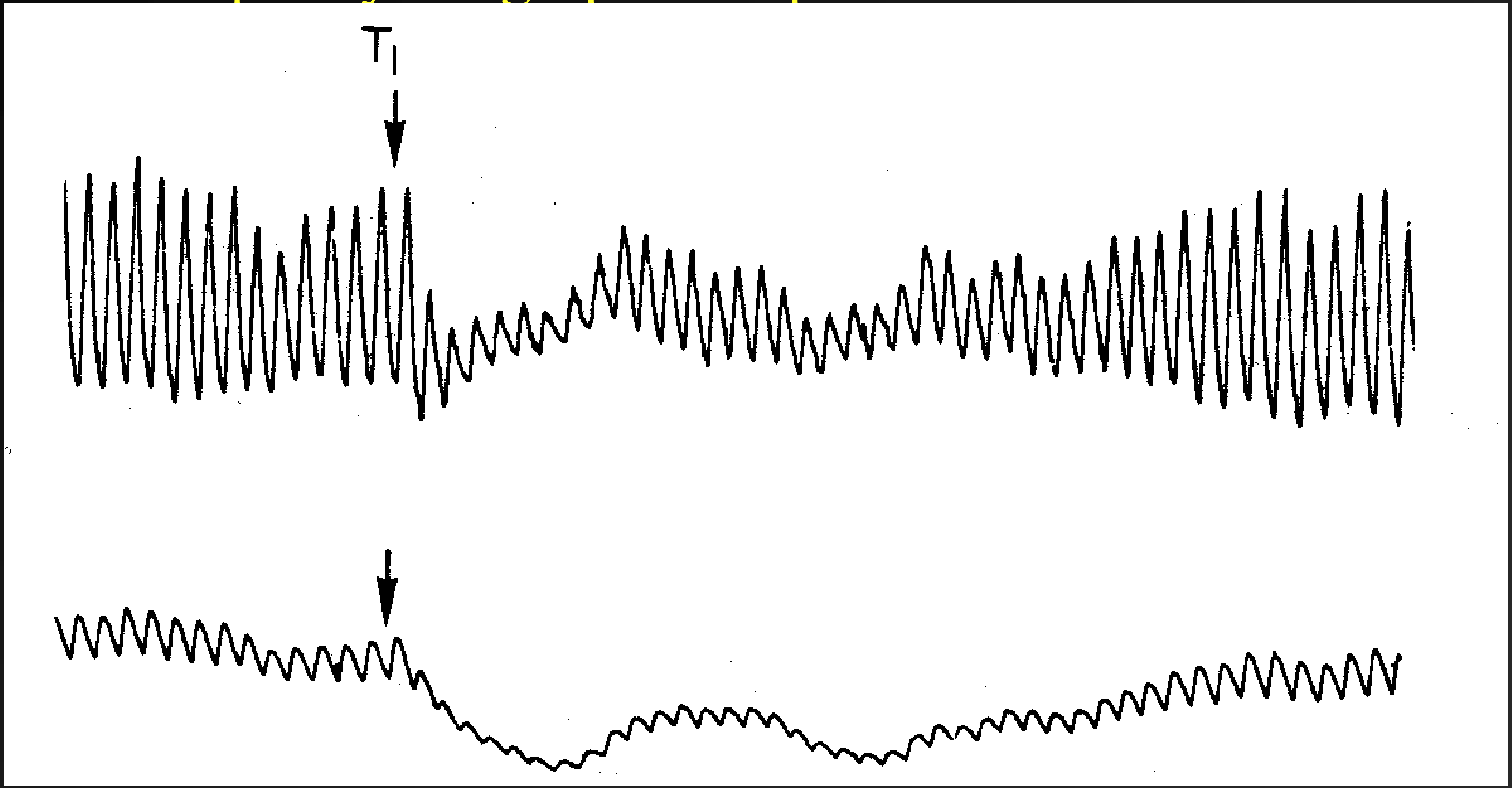


~LVET

Increase in Pressure due to opening of Aortic Valve

Dichrotic Notch; closing of valve, end of ejection

Photoplethysmograph: Peripheral Vasoconstriction

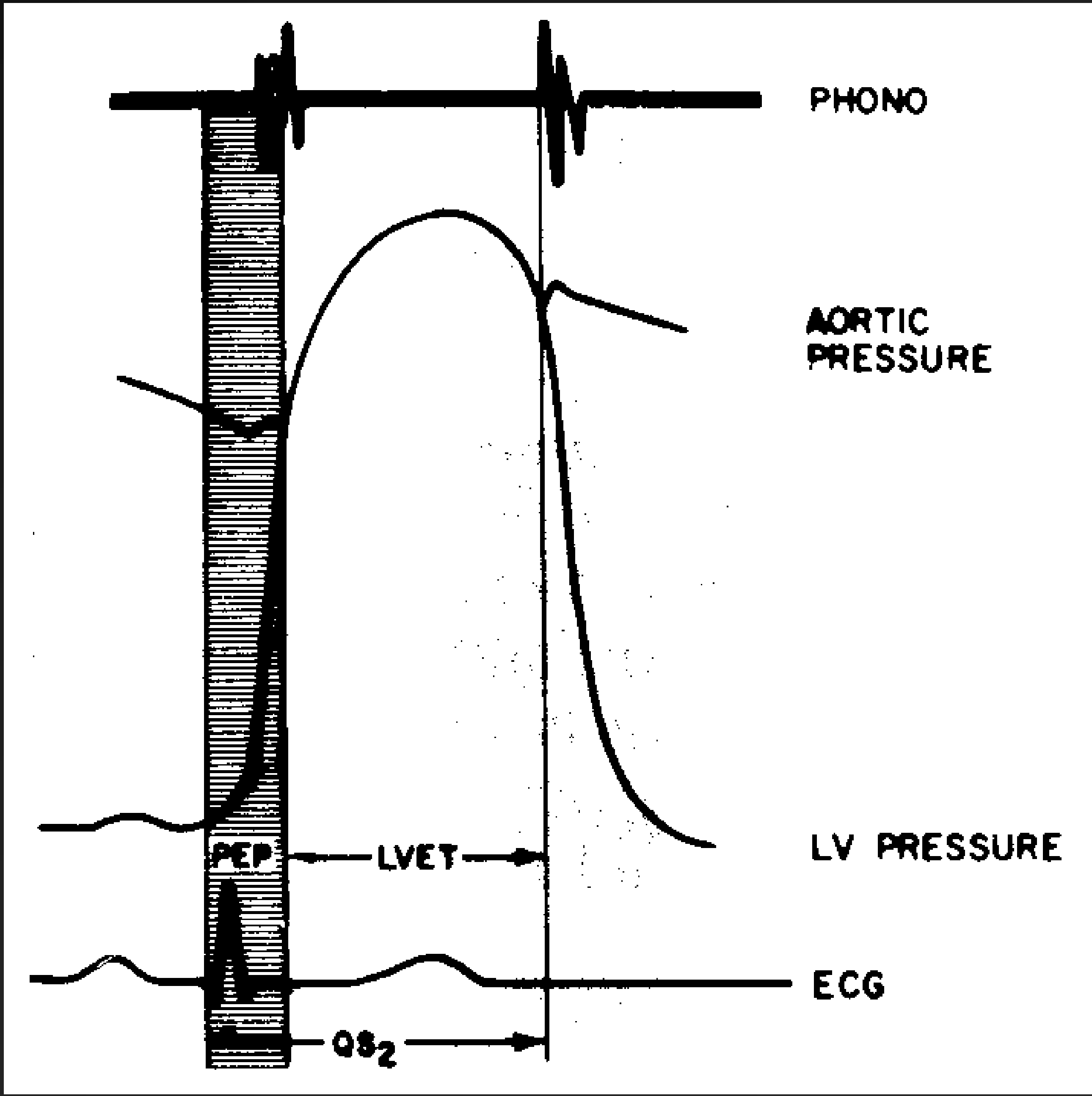


T1 is onset of constriction
Top Panel: Pulse Volume (recorded with 1 sec time constant)
Lower Panel: Blood Volume (no filter)

Measuring contractility with EKG, PCG, and Photoplethysmography

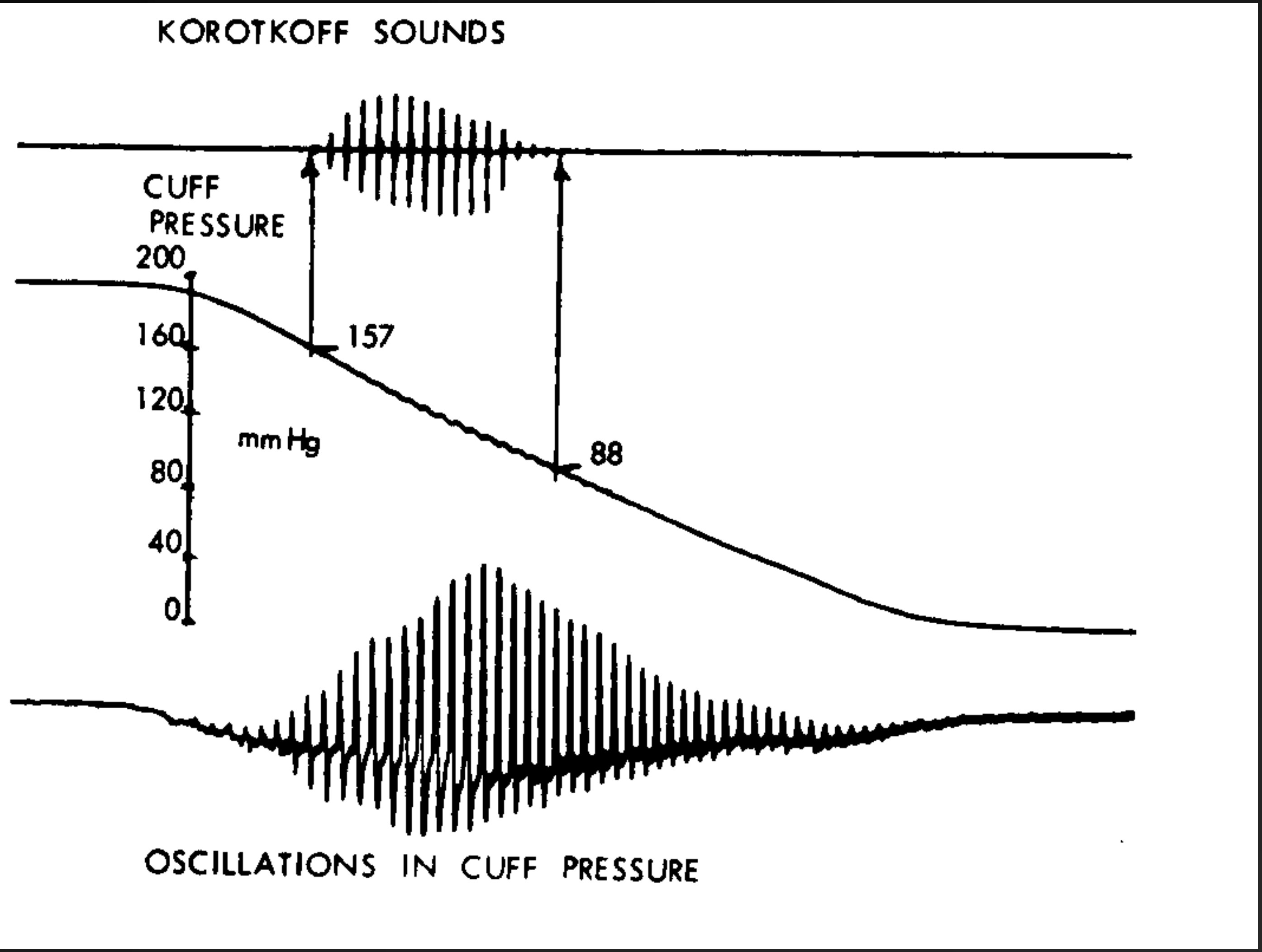
PEP = Pre-ejection period
LVET = Left Ventricular Ejection Time
= Upswing of pressure wave to S2
Electromechanical Systole = Q to S2
PEP = EMS – LVET

PEP reflects sympathetic influence on cardiac contractility



After Newlin & Levenson (1979) *Psychophysiology, 16*, 546-553

Measuring Blood Pressure



Auscultatory Technique

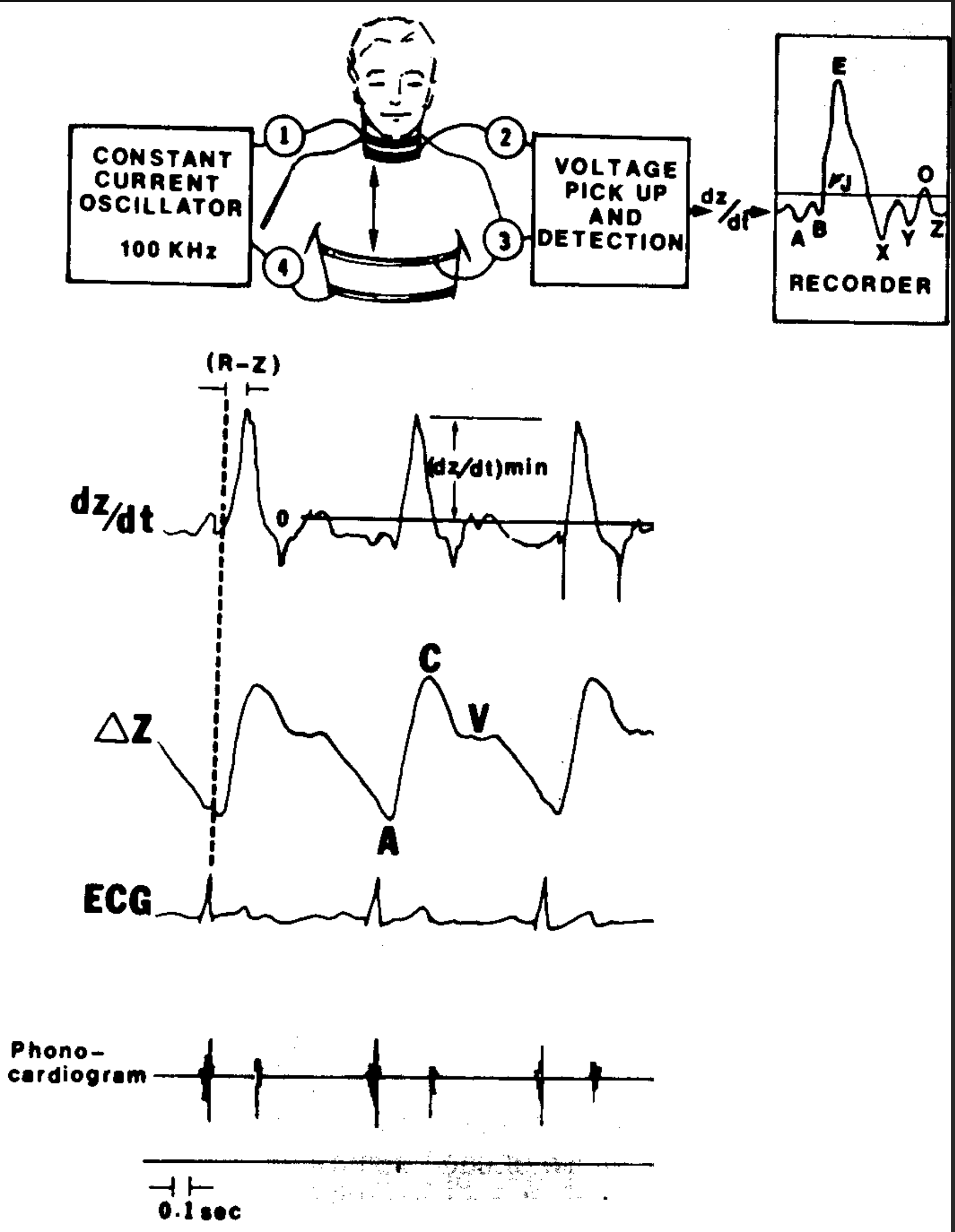
- Not good for instantaneous readings
- Not good for repeated readings

Ballistocardiography

- Imagine
  - On a chair on a platform on an air hockey table
  - Cardiac events cause movement of platform
- New applications:
  - Finding individuals hiding in vehicles
  - Finding individuals stuck in rubble

Impedance Cardiography

- Low energy high-frequency AC passed through thoracic region
- Changes in impedance to signal created by mechanical events of cardiac cycle, especially changes in thoracic blood volume
- ΔZ is change in impedance
- Dz/dt is 1st derivative of impedance signal Z
- R-Z is time from r-wave to peak ventricular contraction indicated in Z signal
- The "Heather" index – divide dz/dt by R-Z interval; putative measure of heart's ability to respond to stress

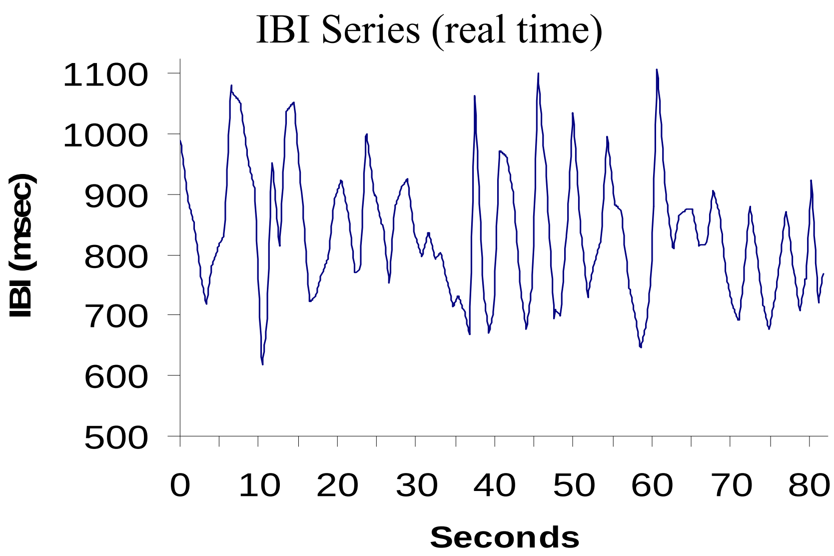


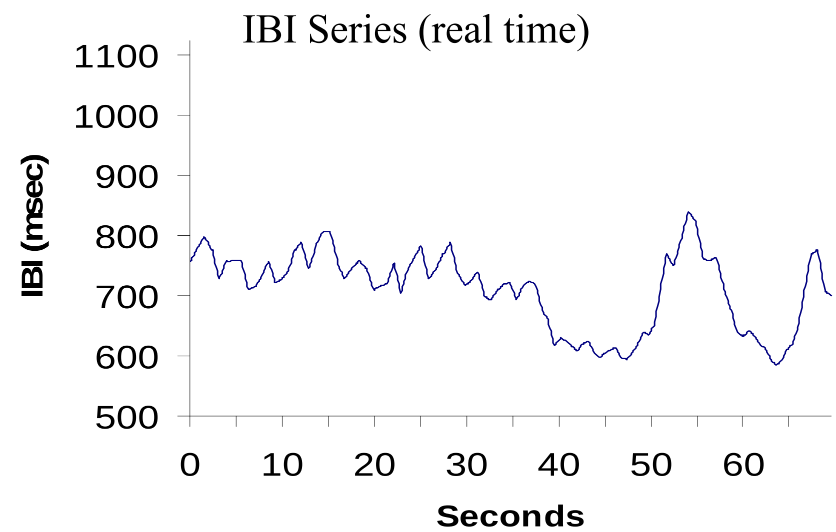
Measuring Vagal Influence

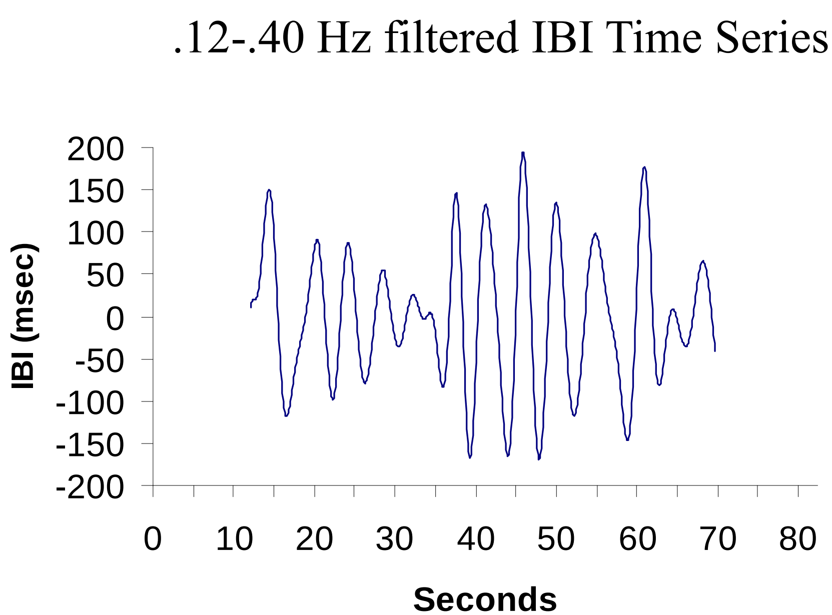
- Descending Vagal Influence slows HR
- Respiration interrupts this vagal influence
- The size of periodic oscillations due to respiration can therefore index the strength of the Vagal influence
  - Note, however, that under some circumstances, there can be dissociation between RSA and presumed central cardiac vagal efferent activity (cf., Grossman & Taylor, 2007)
  - Concerns over changes in rate, and to lesser extent depth
  - See special issue of *Biological Psychology*, 2007 for more in depth treatment of these issues and more!
- Demo with QRSTool

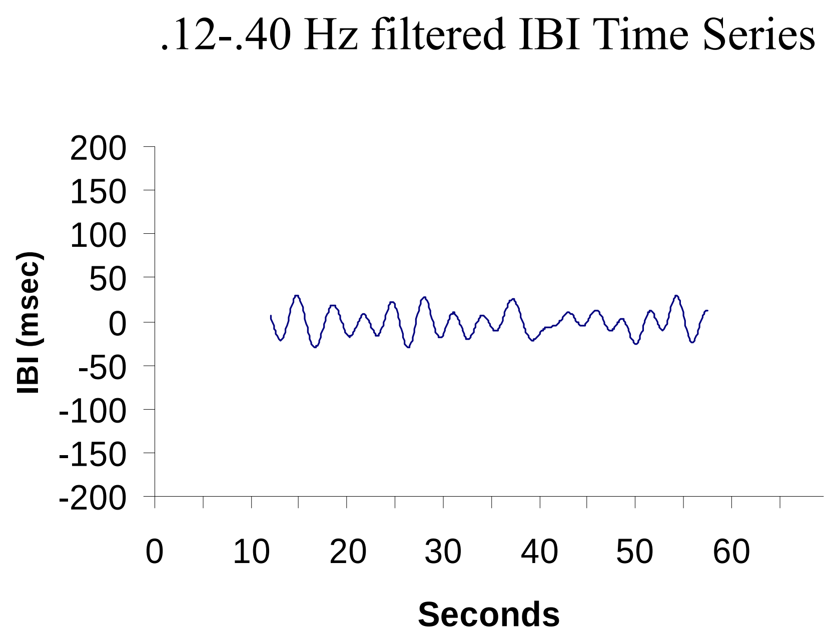
Abbreviated History of HR Variability (with thanks to Porges, 2007)

- Physiology treated HR as DV, similar to behavior
- Dominance of behaviorism emphasized control over the DV (behavior)
- Changes in HR unrelated to the manipulation considered noise
  - Lacey (1967) and Obrist (1981) had models related to attention, and metabolic demand, but HR *variability* did not fit in either model
  - Via appropriate experimental design, HR should be entirely under the control of experimental or environmental demands
- Nonetheless, history of quantifying HR variability dates to the 1950's with case report long before that:
  - 1958: Lacey and Lacey, greater HRV associated with greater impulsivity
  - 1915: Eppinger and Hess, described a vagotonic syndrome with clinical features that included an exaggerated RSA
  - Interest in HRV as an *individual difference* variable, however, really starts with the work of Steve Porges


IBI Series (real time)
IBI (msec)
1100
1000
900
800
700
600
500
0
10
20
30
40
50
60
70
80
Seconds


IBI Series (real time)
IBI (msec)
1100
1000
900
800
700
600
500
0
10
20
30
40
50
60
Seconds


.12-.40 Hz filtered IBI Time Series
IBI (msec)
200
150
100
50
0
-50
-100
-150
-200
0
10
20
30
40
50
60
70
80
Seconds


.12-.40 Hz filtered IBI Time Series
IBI (msec)
200
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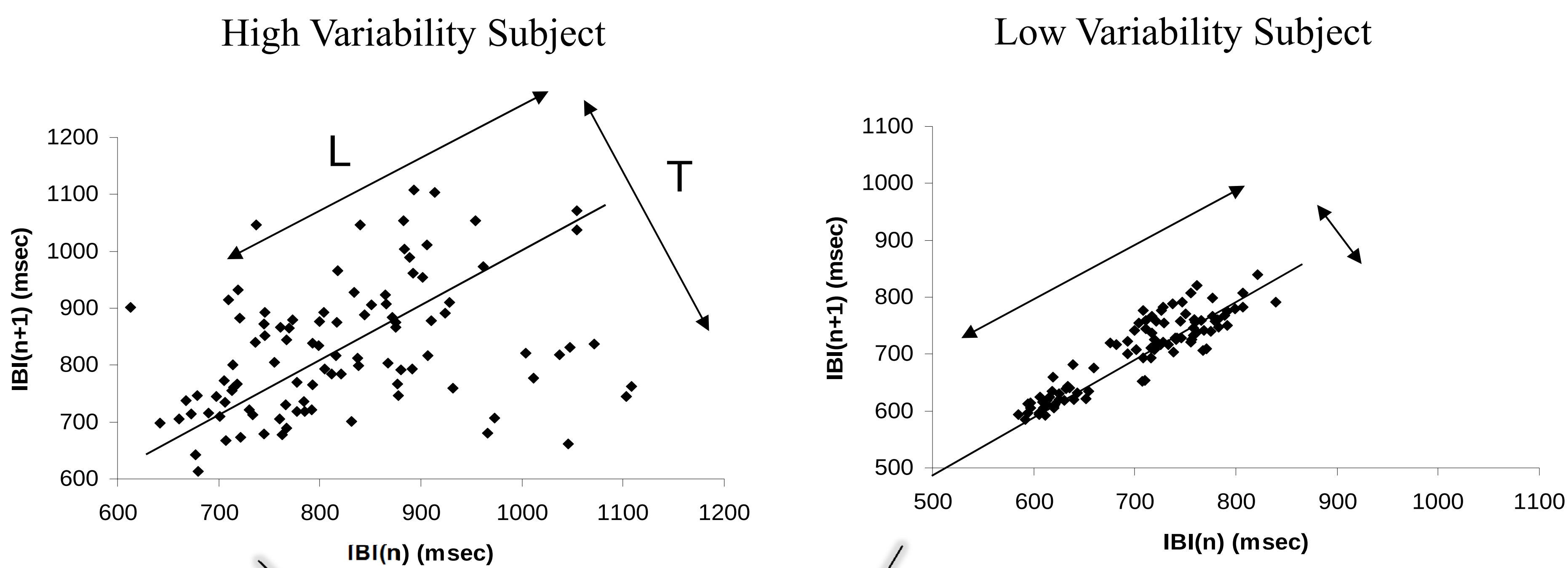


	Rate	
73.3	HR	85.7
832.3	IBI	707.7
	Total Variability	
9.2	HRV	8.3
112.4	SDNN	66.3
132.8	RMSSD	27.7
	"Sympathetic"	
1.4	CSI	4.7
	"Parasympathetic"	
57.1	PNN50	10.8
97.6	MCD	22.0
5.3	CVI	4.5
8.8	RSA	5.3

Metrics output by CMetX, with notes concerning computation

Metrics of rate, which are influenced by both parasympathetic (PNS) and sympathetic (SNS) influences

- Mean interbeat interval (IBI), calculated as simple average of IBIs
- Mean heart rate (HR), calculated as the average of the rate-transformed IBIs, not as the rate-transformation of the average IBI

Metrics summarizing total heart rate variability, which are influenced by both SNS and PNS

- Heart rate variability (HRV), operationalized as the natural log of the variance of the IBI time series
- Standard deviation of IBI series (SDNN); NN in the acronym SDNN is the abbreviation for "normal-to-normal intervals," which is the artifact-free IBI series
- Root mean square of successive differences between IBIs (RMSSD)

Putative sympathetic metric

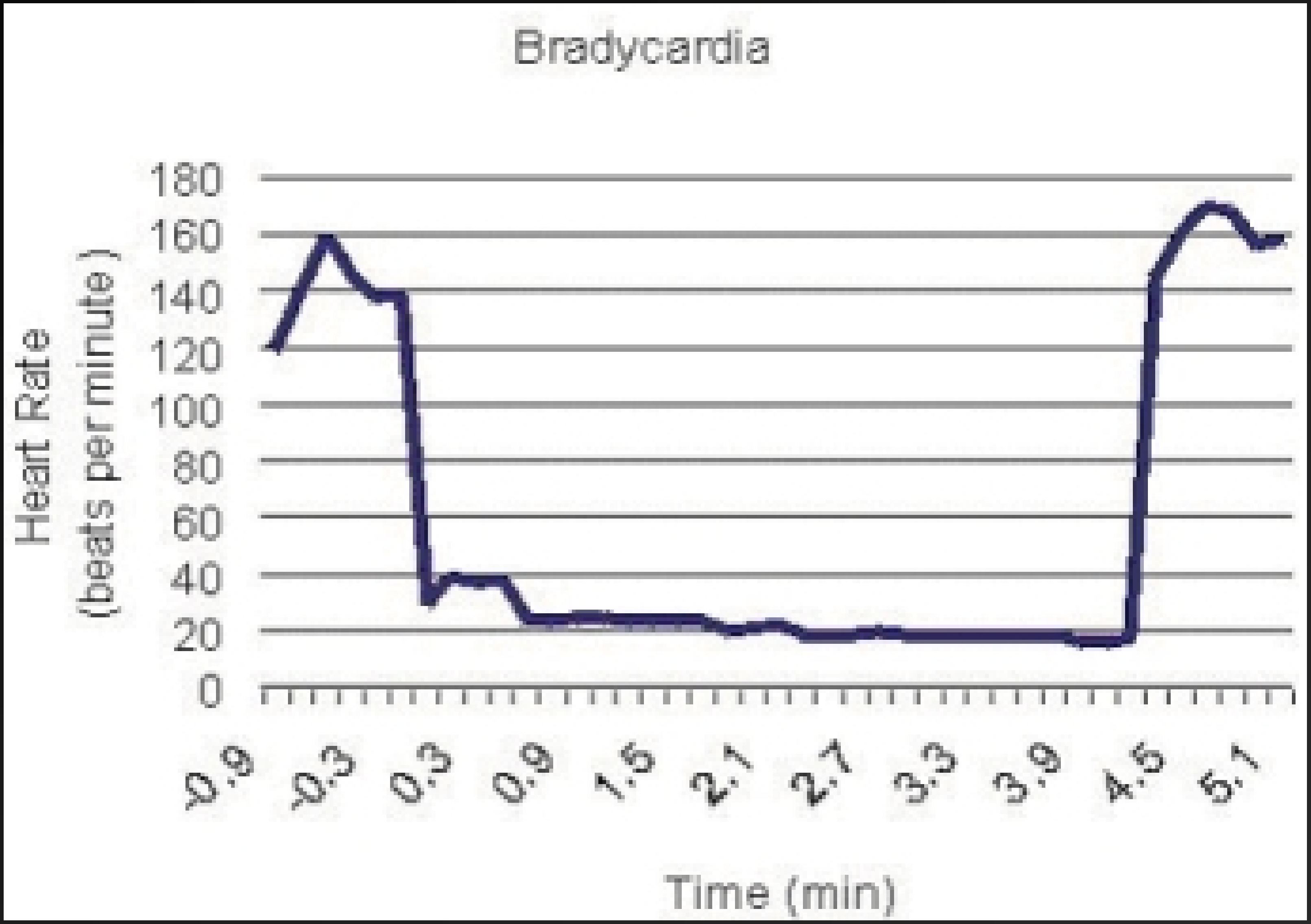
- A cardiac sympathetic index (CSI; Toichi et al. (1997), see Fig. 1)[a]

Putative parasympathetic metrics

- Mean absolute successive IBI difference (MSD)
- Proportion of consecutive IBI differences >50 ms (pnn50)
- Respiratory sinus arrhythmia (RSA), defined as natural log of band-limited (.12–.40 Hz) variance of IBI time series
- A cardiac vagal index (CVI; Toichi et al. (1997), see Fig. 1)[a]

Cardiac Vagal Control and Modulation

- Two Vagal Efferent Branches which terminate on SA Node (Porges 1995, 2003, 2007)
  - Reptilian “Dumb”: Dorsal Motor Nucleus
    - Massive reduction in HR & conservation of oxygen.
    - Dive reflex -- cold water on the face during breath hold
  - Phylogentically newer “smart” Vagus
    - Orginates from Nucleus Ambiguous
    - Modualtes influence to:
      - Promote attentional engagement, emotional expression, and communication.
    - Mobilizes organism to respond to environmental demands
      - Phasicly withdraws inhibitory influence, increasing HR
      - Upon removal of the environmental stressor, resumes its efferent signal
        - Slowing heart rate
        - Allows the organism to self-sooth
- This polyvagal theory is not without its critics (e.g., Grossman & Taylor, 2007).



Bradycardia observed in a diving seal. **Data adapted from R.S. Elsner (1998), courtesy of http://www.deeperblue.net/article.php/225**

	ANS Component	Behavioral Function	Lower motor neurons
III	Myelinated vagus *(ventral vagal complex)*	Social communication, self-soothing and calming, inhibit "arousal"	Nucleus ambiguus
II	Sympathetic-adrenal system	Mobilization (active avoidance)	Spinal cord
I	Unmeyelinated vagus *(dorsal vagal complex)*	Immobilization (death feigning, passive avoidance)	Dorsal motor nucleus of the vagus

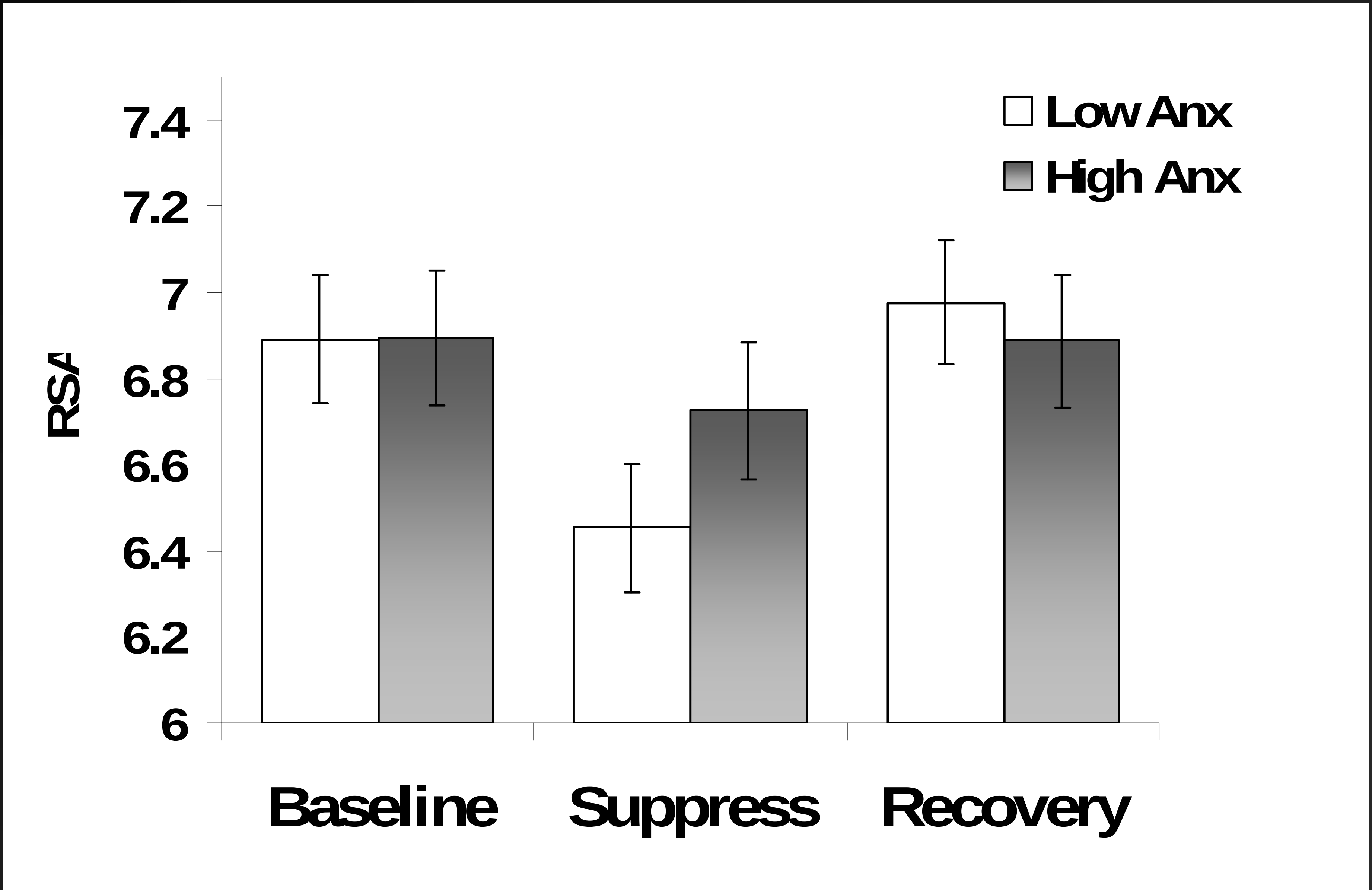
Fig. 1. Phylogenetic stages of the polyvagal theory.

Porges, 2007

Tonic Vs Phasic

- Tonic Level indexes capacity
- Phasic change indexes actualization of that capacity
- Attention
  - higher vagal "tone" was associated with faster reaction time to a task requiring sustained attention
  - Hyperactive kids treated with Ritalin (Porges, Walter, Korb, & Sprague, 1975).
    - attentional skills improved
    - appropriate task-related suppression of heart rate variability was observed while performing the task requiring sustained attention
- Emotion
  - Beauchaine (2001):
    - low baseline vagal "tone" is related to negative emotional traits
    - high vagal withdrawal is related to negative emotional states

Task-related and Emotion-related modulation



Movius & Allen, 2005

Individual Differences in Cardiac Vagal Control (aka "Trait Vagal Tone")

- Infants
  - Various sick infants have lower vagal tone (Respiratory Distress Syndrome, Hydrocephalic)
  - Infants with higher vagal tone (Porges, various years)
    - More emotionally reactive (both + & -)
    - More responsive to environmental stimuli (behaviorally and physiologically)
- Anxiety Disorders
  - Lower Vagal Tone in GAD (Thayer et al., 1996)
  - Lower Vagal Tone in Panic Disorder (Friedman & Thayer, 1998)
- Depression
  - Depression characterized by lower Vagal tone?
  - State dependent? (Chambers & Allen, 2002)

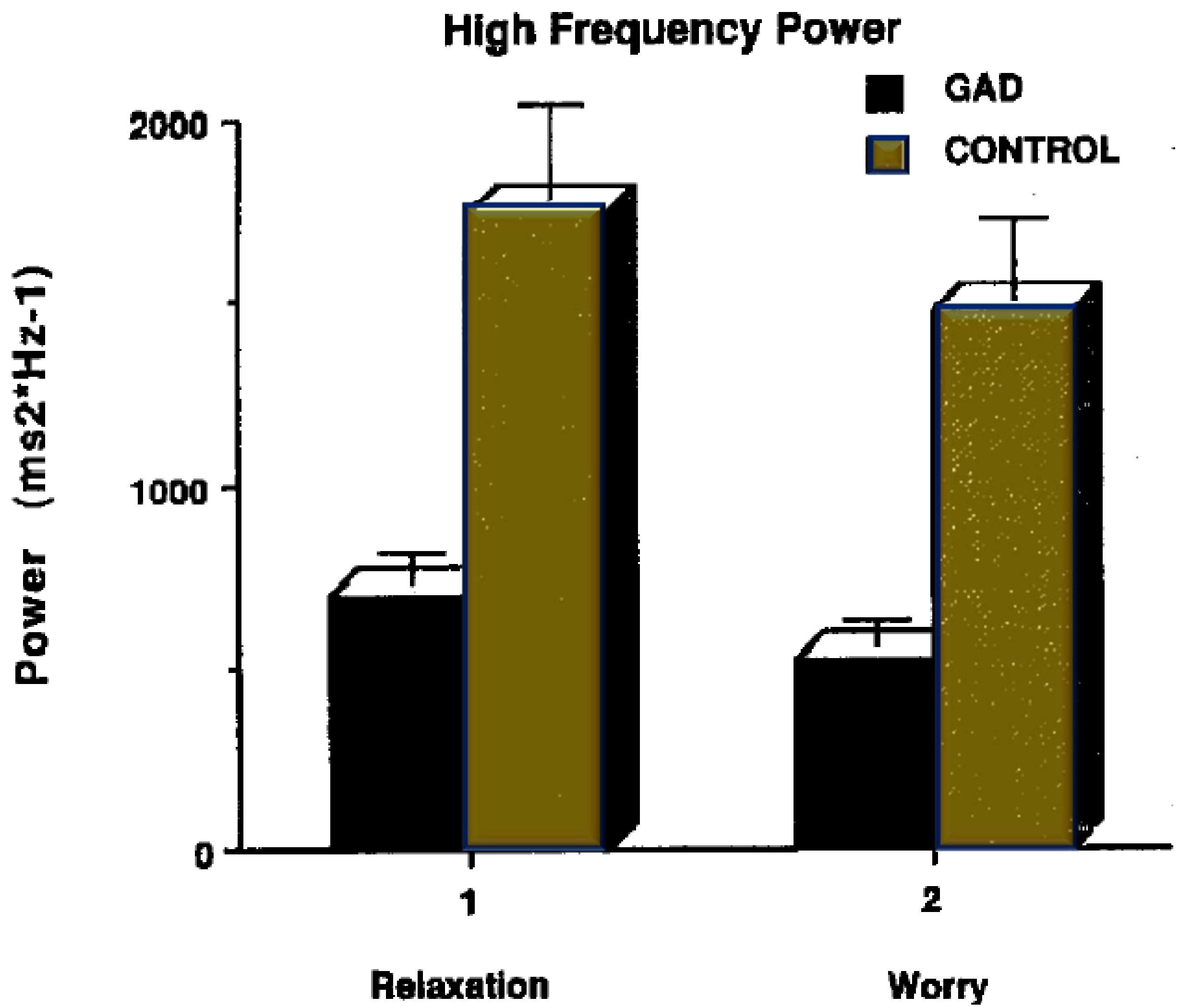
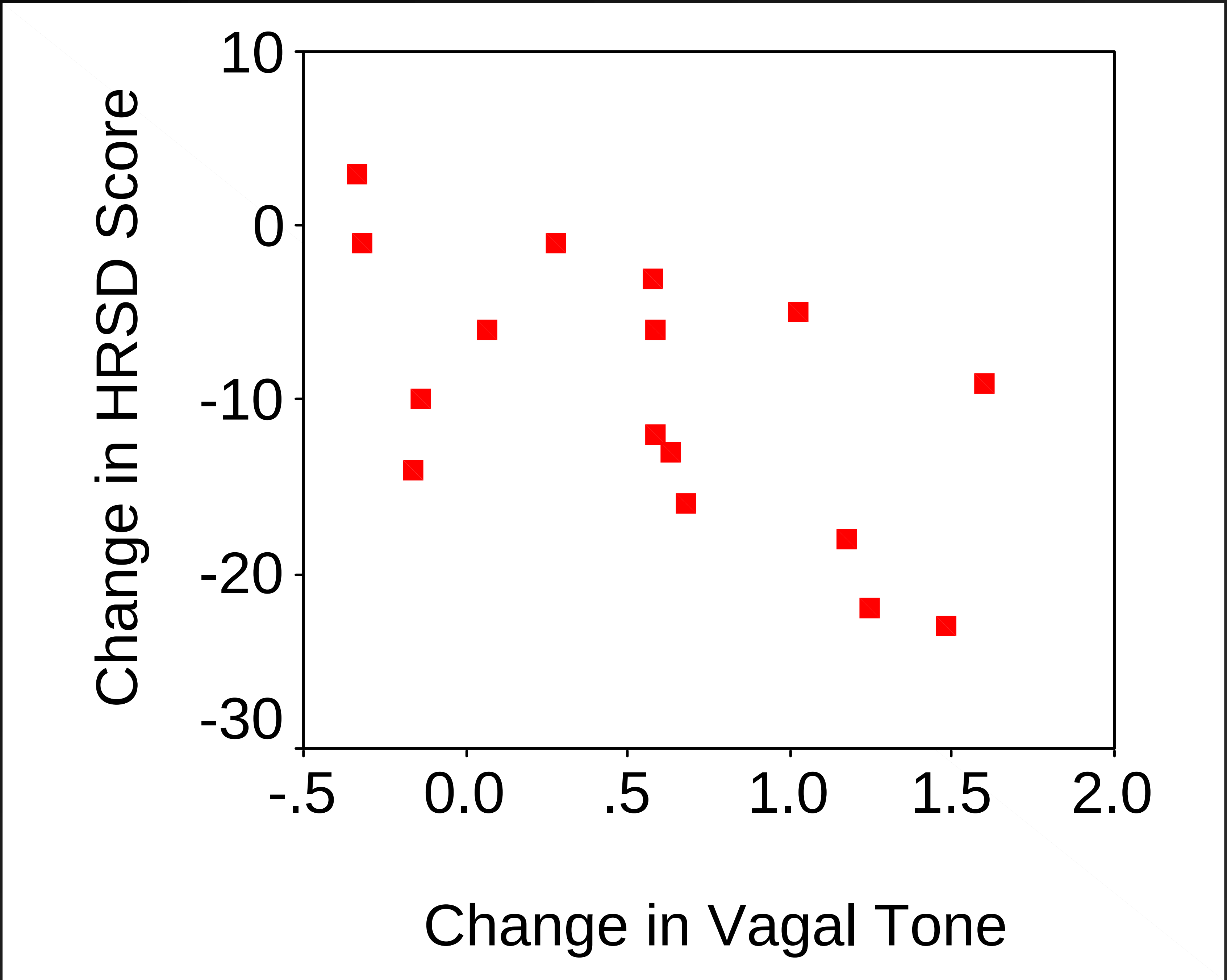


Figure 1. Power in the high frequency (respiratory) component of heart period variability in GAD patients and controls during relaxation and worry.

Table 1
Significant contrasts among panickers, blood phobics, and controls

Variable	Panic (mean, S.D.)	Blood phobic (mean, S.D.)	Control (mean, S.D.)	T ratio, df, p value
IBI (ms)	761.8 (141.0)	837.1 (92.4)	905.2 (132.5)	P < B 4.59 (215) $p < 0.001$ P < C 7.65 (214) $p < 0.001$ B < C 4.30 (207) $p < 0.001$
VAR (ms^2)	3942 (4009)	4334 (2663)	6112 (4563)	P < C 3.70 (214) $p < 0.001$ B < C 3.44 (207) $p < 0.001$ P = B N.S.
MSD (ms)	44.4 (31.2)	55.6 (22.7)	71.4 (32.1)	P < B 3.05 (215) $p < 0.001$ P < C 6.34 (214) $p < 0.001$ B < C 4.11 (207) $p < 0.001$
HF power (ms^2 Hz^{-1})	991 (1225)	1385 (1073)	2239 (1911)	P < B 2.49 (212) $p < 0.01$ P < C 5.67 (212) $p < 0.001$ B < C 3.90 (203) $p < 0.001$
LF/HF	2.1(2.5)	1.3 (1.8)	1.0 (1.5)	P < B 2.41 (209) $p < 0.005$ P < C 3.64 (203) $p < 0.001$ B = C N.S.

P, panic; B, blood phobic; C, control.



Chambers and Allen (2002) *Psychophysiology*

Can Vagal Control predict development of anxiety following stressors?

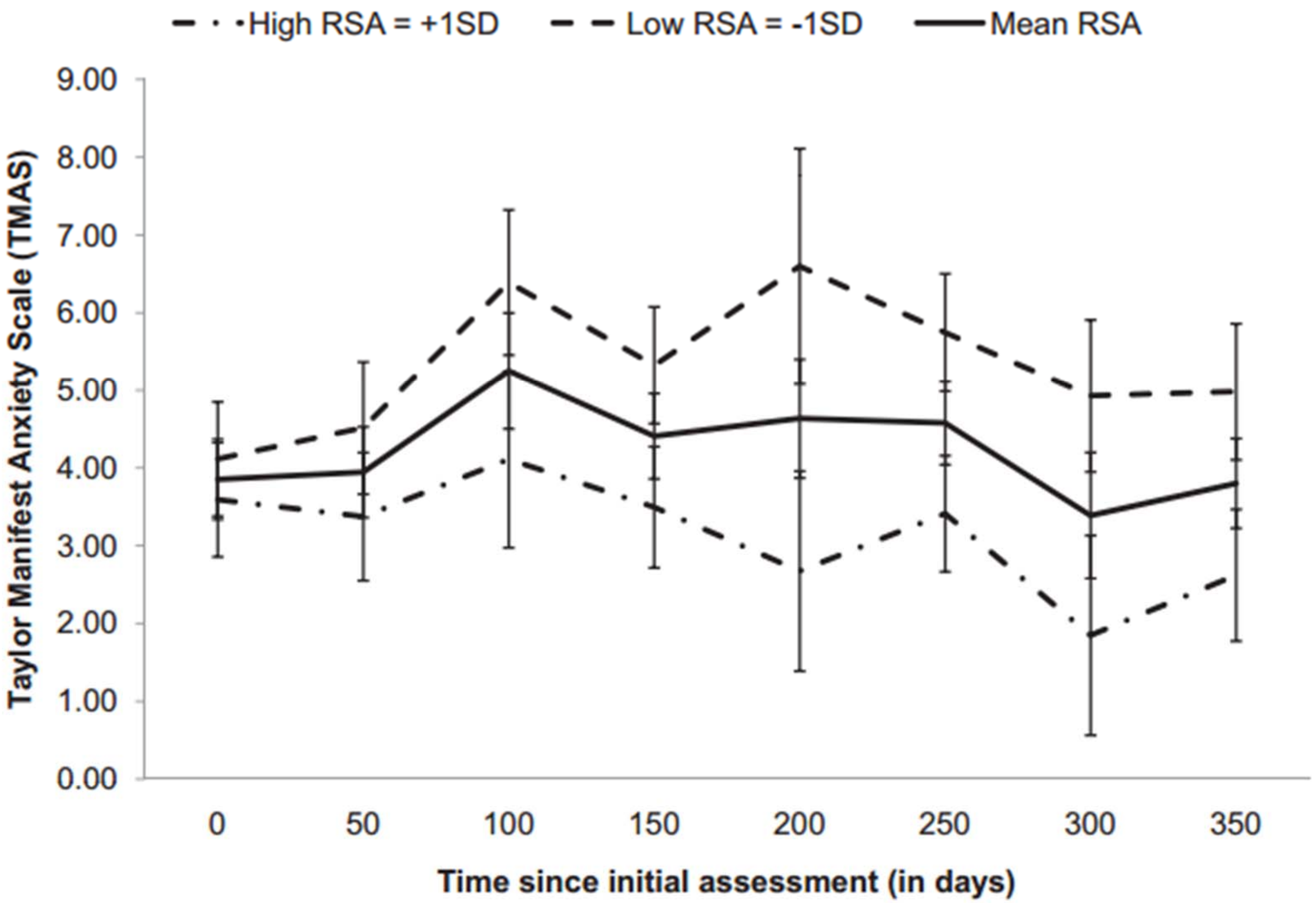
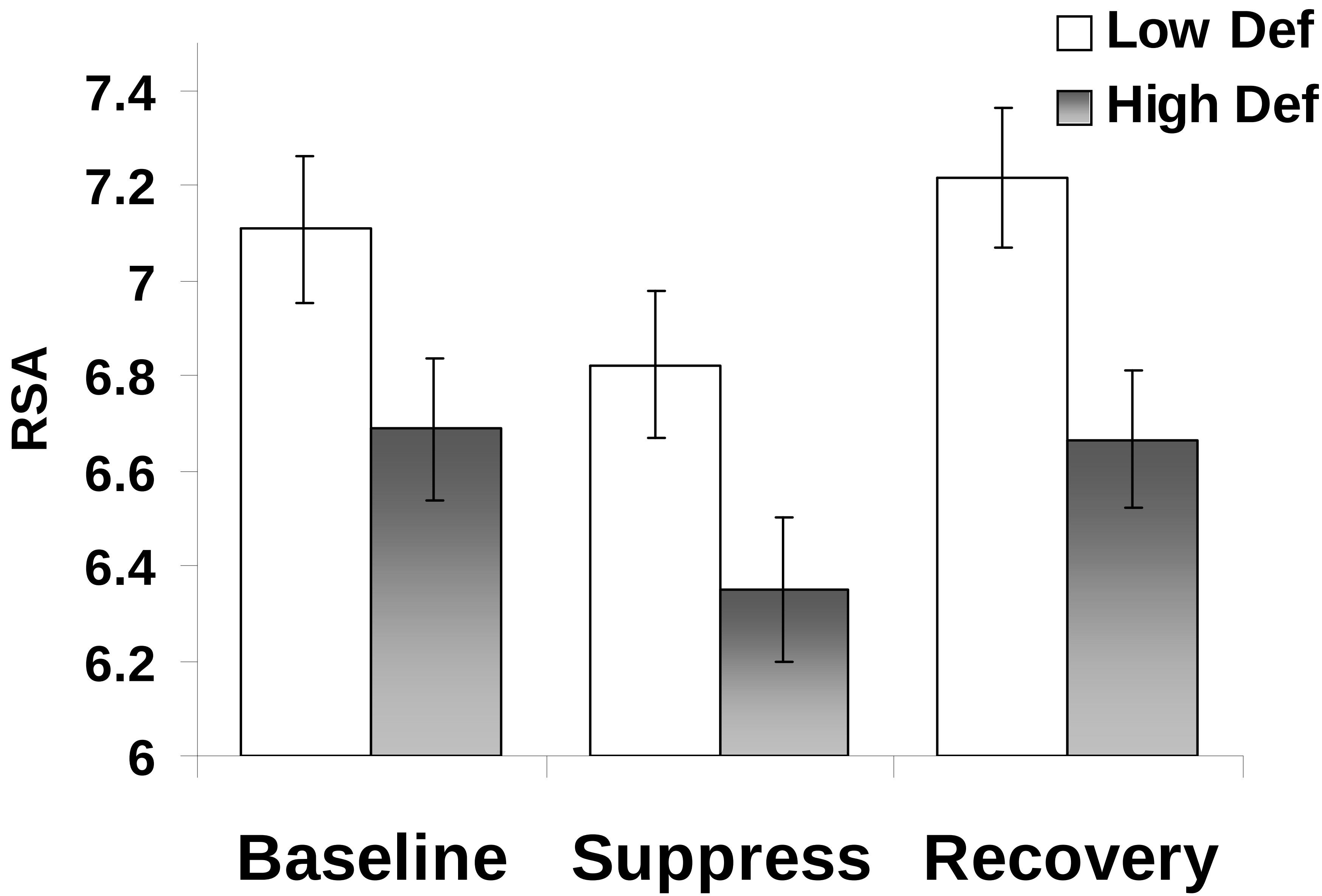


Fig. 1. Effect of the interaction between RSA adjusted for age and Time since initial assessment on TMAS over a 1-year period. Although RSA is a continuous variable, for illustrative purposes, its effect on TMAS is plotted at ±1 SD from the mean. Error bars represent standard errors. RSA: respiratory sinus arrhythmia; SD: standard deviation; TMAS: Taylor Manifest Anxiety Scale.

Kogan, Allen, Weihs (2012)
Biological Psychology

Vagal Control and Defensive Coping

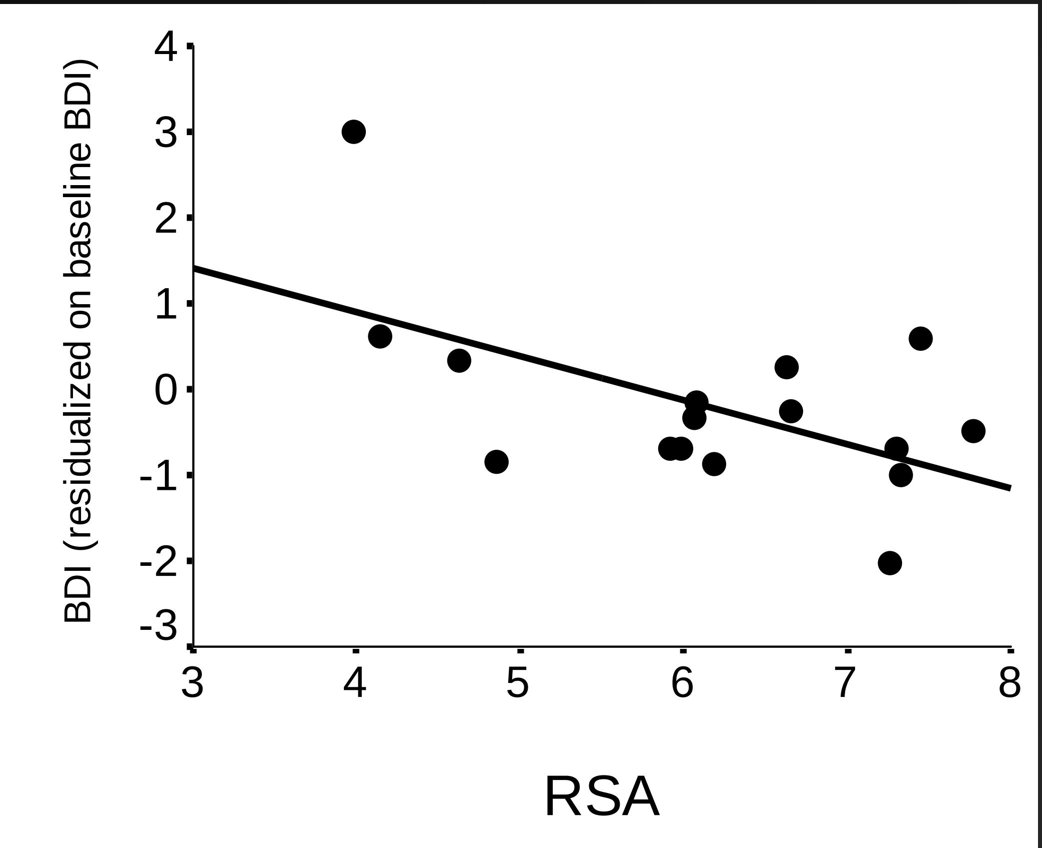


Movius & Allen, 2005

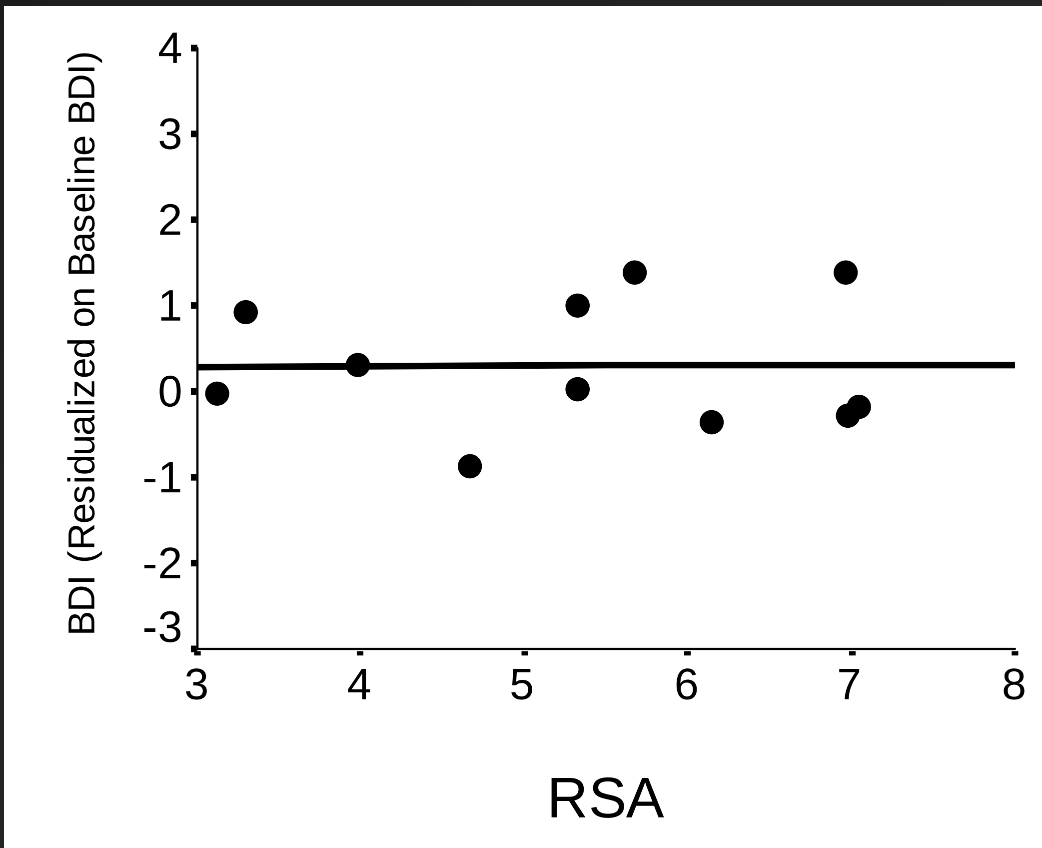
Trait Vagal Tone as Moderator of Response following Bereavement

- ❑Bereavement as a period of cardiovascular risk
- ❑Disclosure as an intervention for Bereavement (O'Connor, Allen, Kaszniak, 2005)
- ❑Overall, all folks get better, but no differential impact of intervention
- ❑BUT… Vagal Tone as moderator

Intervention Group



Control Group



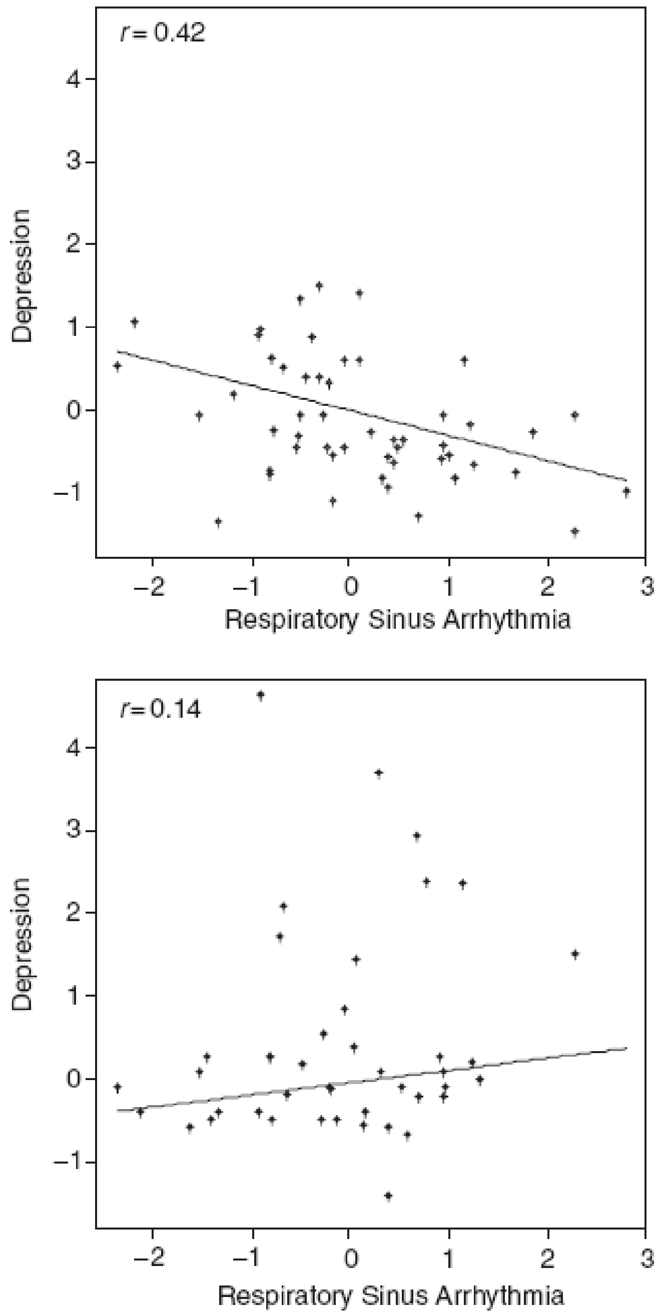


Figure 1. Scatterplot, prediction line, and prediction equation for the relationship between respiratory sinus arrhythmia (log of the variance of the band-limited [.12–.40 Hz] IBI series) and depression score (residualized on baseline depression score), for the disclosure group (top panel) and the control group (bottom panel). Negative depression score represents improvement from baseline to follow-up.

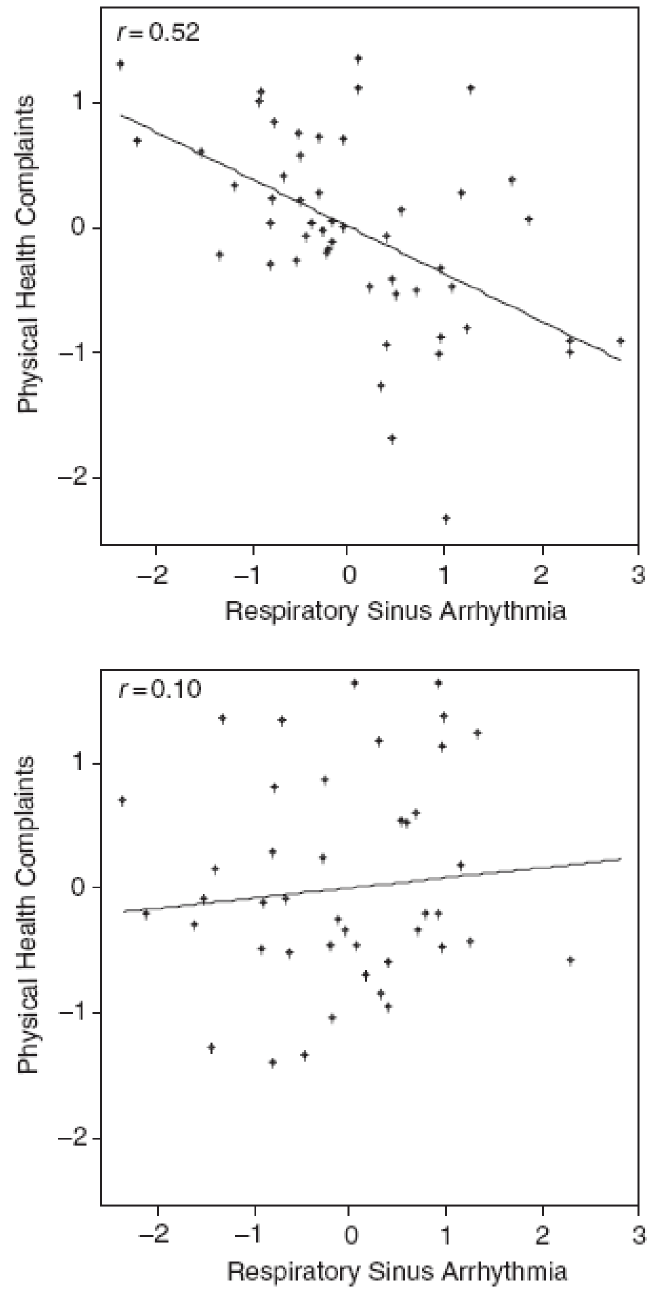
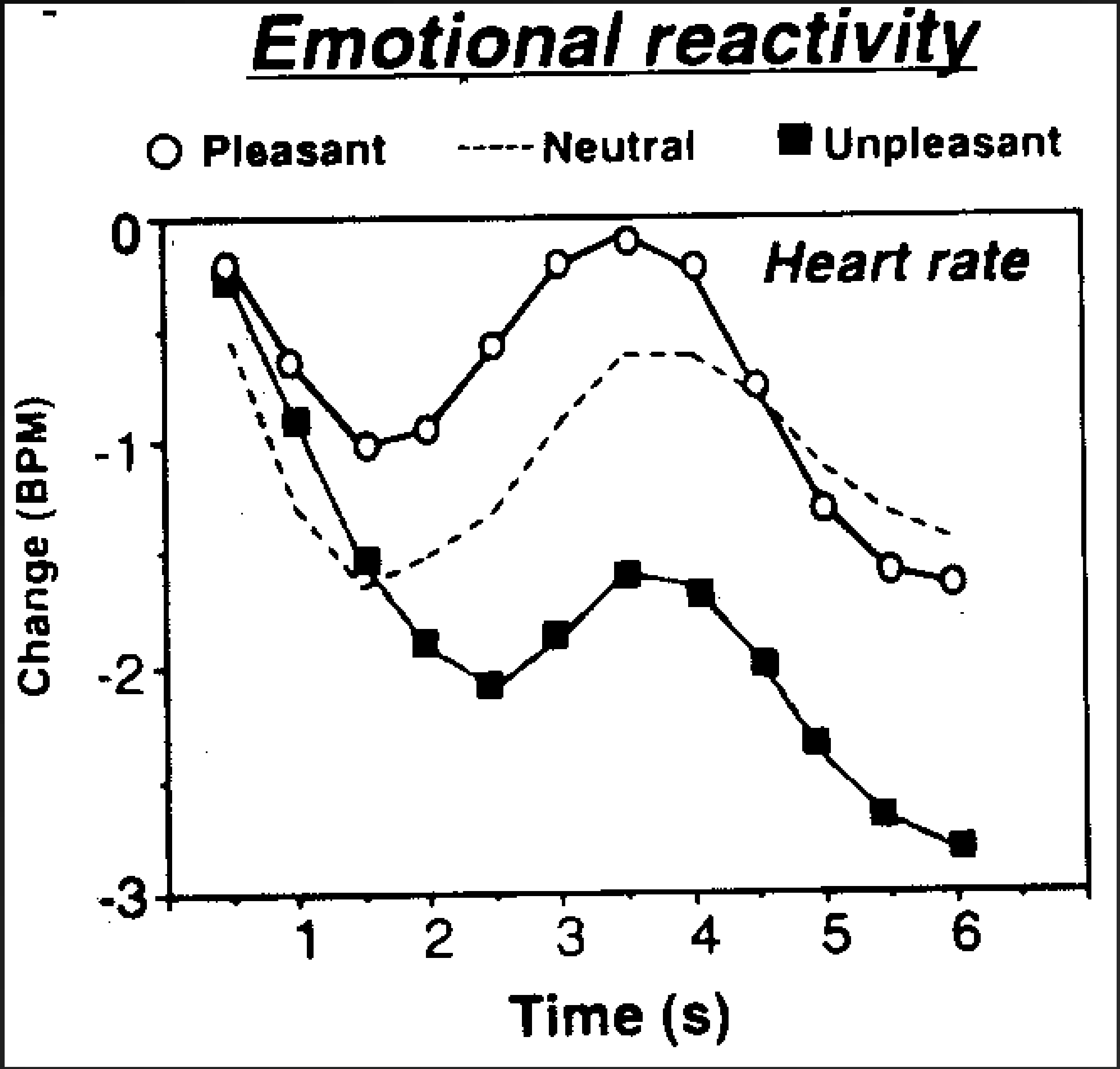
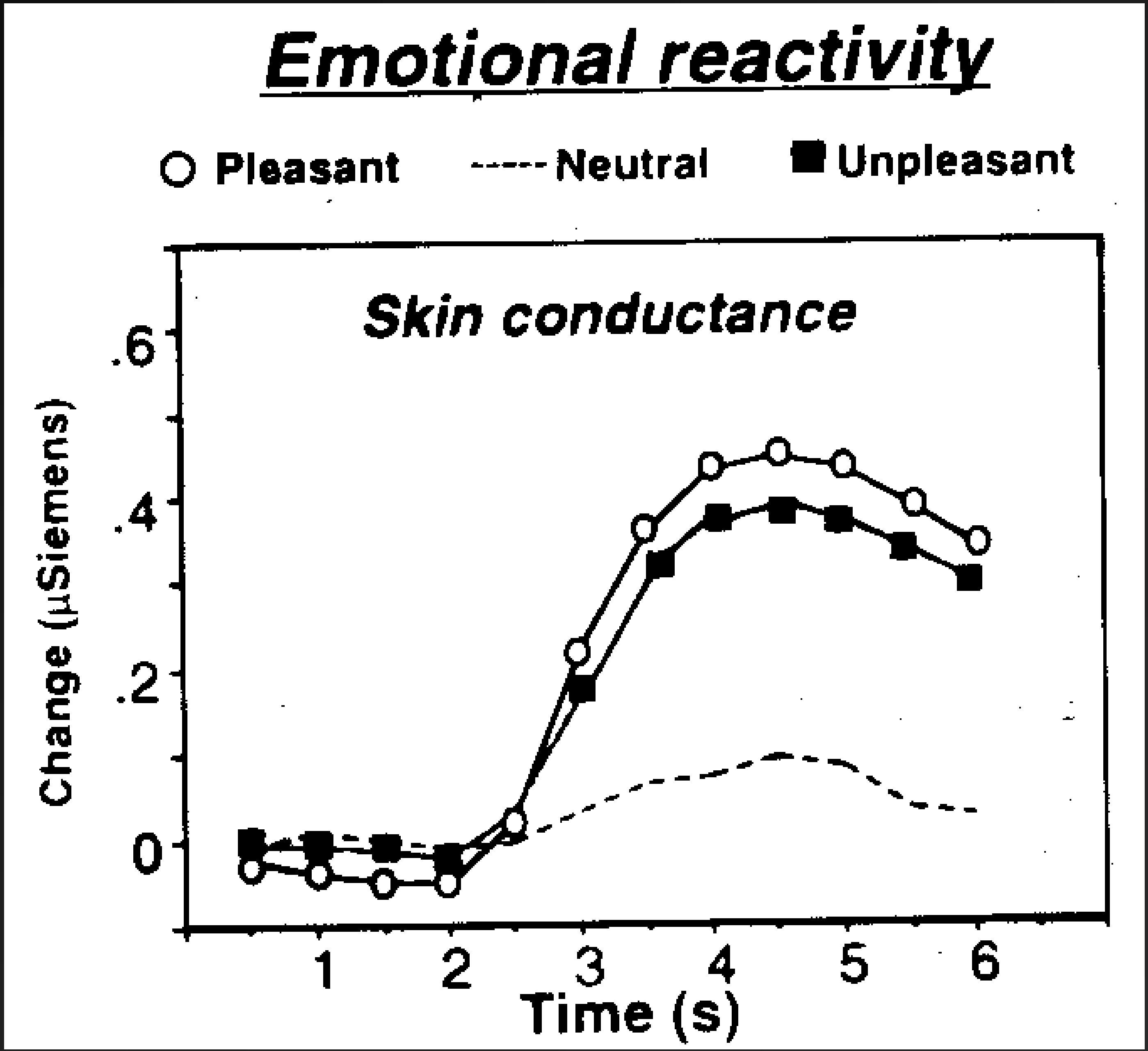


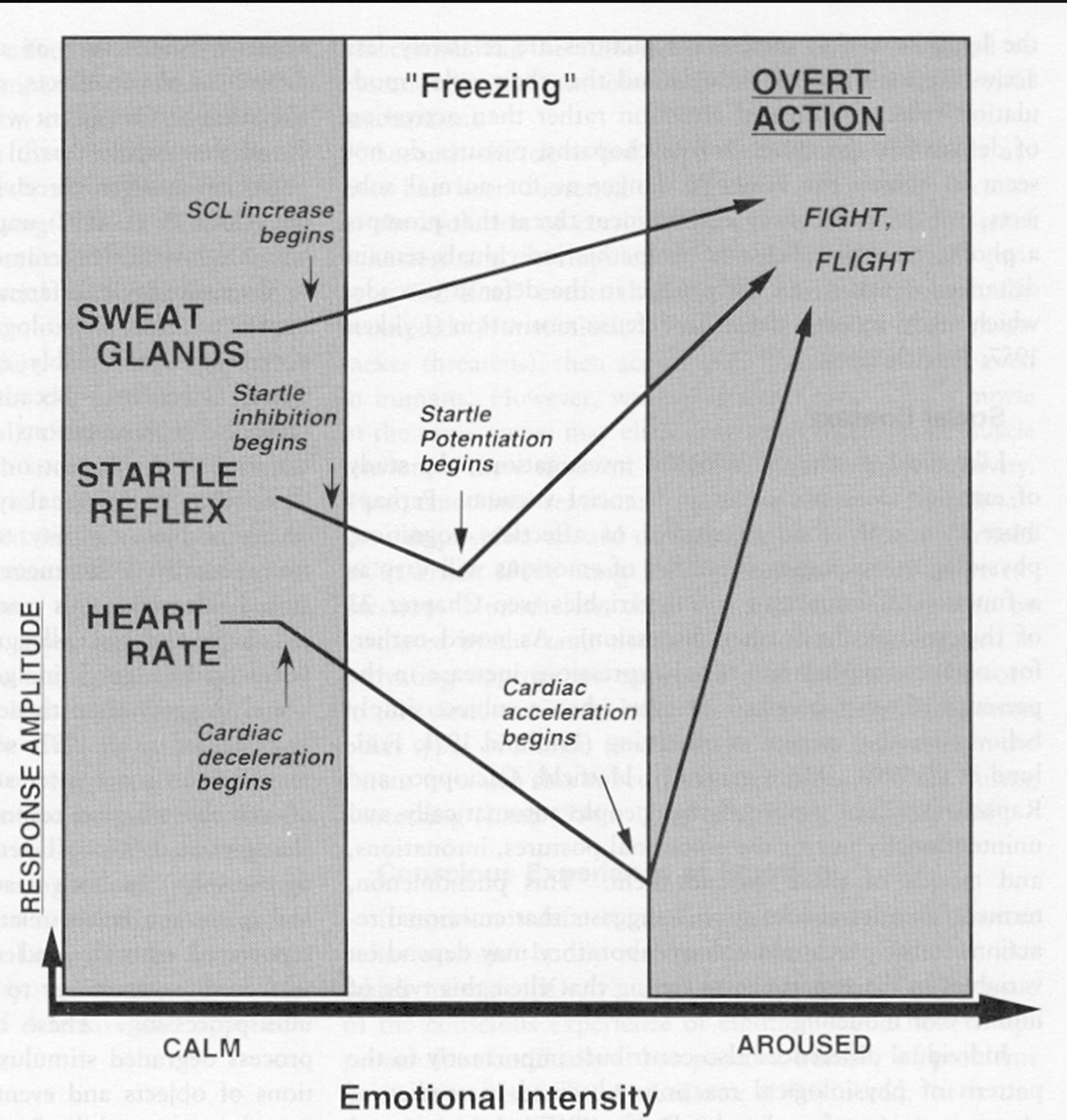
Figure 2. Scatterplot, prediction line, and prediction equation for the relationship between respiratory sinus arrhythmia (log of the variance of the band-limited [.12–.40 Hz] IBI series) and physical health complaint score (residualized on baseline physical health complaints score) for the disclosure group (top panel) and the control group (bottom panel). Negative physical health complaint score represents improvement from baseline to follow-up.

Orienting, Attention, and Defense



SCR (by contrast)




"Freezing"
OVERT ACTION
SCL increase begins
FIGHT, FLIGHT
SWEAT GLANDS
Startle inhibition begins
Startle Potentiation begins
STARTLE REFLEX
HEART RATE
Cardiac acceleration begins
Cardiac deceleration begins
RESPONSE AMPLITUDE
CALM
AROUSED
Emotional Intensity

OR Vs DR